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THE WAR IN MADAGASCAR.

MADAGASCAR is a large island separated by the Mozambique Channel from Southeastern Africa. It is about 975 miles long and 358 miles broad. Area 230,000 square miles. Its population is 3,500,000, the capital is Antananarivo, a well built town of 100,000 inhabitants, which is situated on a lofty hill about 200 miles inland. The ports of Madagascar are Tamatave and Mojanga. An enormous mountain mass traverses the island from north to south, the soil on the eastern slopes is fertile, and the island has rich deposits of iron, silver, copper and salt, there are also forests of valuable timber. The principal exports are cotton, hides, gum, India rubber, wax, sugar, rice, lard, vanilla and coffee. Cattle herding and agriculture are the principal occupations. The climate is very hurtful to Europeans. The Hovas are the predominant tribe of the island, and they hold the other Malagasy tribes in a condition of practical slavery. The government is an absolute monarchy, the Queen Ranavalona III being assisted by a council of nobles and heads of clans, chosen by herself. The power is really in the hands of the Prime Minister Rainilaiarivony, who is husband of the Queen. By a treaty of December, 1885, a French resident lives at the court and controls foreign relations, so that the country is virtually a French protectorate. During 1893 much friction existed between the Hovas government and the French authorities. In 1894 in consequence of various disturbances in which the French resident was threatened with death, the French military force at Madagascar was greatly increased. Several Frenchmen were assassinated, and

THE FRENCH EXPEDITION TO MADAGASCAR—LANDING CATTLE FOR THE ARMY.

the result was that on November 10, 1894, diplomatic relations were broken off, and since this time a French army has been attempting to make the French protectorate of the island effective. The French have had considerable liberty of action in Madagascar on account of existing agreements which protect her from any foreign interference. The Hovas works, near Tamatave, were bombarded by French cruisers on April 4, 1895, and on May 2 the Hovas suffered disastrous defeats at Marovony and Ampihaorama. General Duchesne, who was appointed to the chief command, arrived from France at Majunga May 6, and immediately begun marching on Antananarivo, meeting with considerable opposition.

Our engraving shows the landing of live stock for the French army.

An English military officer, lately employed by the Hova government as commander-in-chief, writes to the London Times as follows:

In the 150 miles of country already covered by General Duchesne's force it is but fair to admit that great difficulties have been overcome, but now they have to deal with mountain ranges and to pass through the fever-stricken district of Vonizongo. Up to the present the French troops have had to make roads at an altitude of 1,500 ft. at the most, but they have yet to scale the heights of Fihaonana, 35 miles from the capital, and the chief town of the Vonizongo district of Imerina, at an altitude of at least 6,000 ft. above sea level. After leaving Andriba, their present position according to the latest telegrams, the expedition will cross a large and well populated valley about six miles in extent to Mangasoavina, from which point right up to the capital they will have to proceed along the top of mountain ridges and through deep valleys and ravines, cutting their way as they go along a track flanked with positions which can be defended with the greatest ease—a route involving, from what I have seen, the greatest engineering difficulties possible.

During the last war with France the intention of the Hovas, in the event of a French advance on the capital (which, of course, never took place), was to mass the whole of the population some 15 or 20 miles from the capital, where the queen herself would have been present to encourage her troops and where the high Hova officials would have been gathered. These were the Hova tactics, and doubtless they are the Hova tactics now.

Asked to explain the attitude of the Hovas toward the French, the late Malagasy commander-in-chief remarked:

"There is a strong party in the capital in favor of the French—composed of members of the cabinet and other high officials. Apart from this section, the Hova people are most inimical to the French, and I do not for a moment suppose they would agree to any terms unless they saw their case to be hopeless. They are, on the contrary, much more likely to sweep away the French party and insist upon proper steps being taken to keep the French out. The Hova officers are one of the great drawbacks. They are greedy and grasping men, who rob the soldiers and think only of their own aggrandizement, and, instead of feeding the troops, steal the ration money.

"Both the queen and prime minister are thoroughly loyal to their country, but are deceived by designing persons. As far as arms and ammunition are concerned, the Hovas have all that can be desired. Their artillery and machine guns are of the latest and most approved patterns, and, numerically, are far superior to those accompanying the French expedition. Their small arms are Sniders and Remingtons, which, if properly handled, are good enough for the purpose required.

"The Hova is a splendid soldier behind earthworks, but incapable of meeting European troops in the open. With regard to the strength of the Malagasy army, while it would be impolitic to go into details, I may say that there are at least 50,000 men armed with breech-loading rifles, and with a splendid artillery, and certainly not less than 150,000 more or less trained men available, but indifferently armed. On the red flag being run up at the palace the whole population who are liable to service would assemble in a few hours and be dispatched to their various stations. A large number of the officers have already had considerable experience in fighting the French, and both they and their men have been for years well versed in military tactics."

On the political future of Madagascar Colonel Shervinton, in conclusion, said:

"The present misrule and the tyranny of the governing classes is such that even French rule would be an improvement. Madagascar has a great future before her with proper European administration. I do not believe the French mean to seize the country, but I think they will be satisfied with the establishment of an effective protectorate. The difficulties of occupying the island as a possession are enormous, and it will probably be administered by Hovas under French official supervision."

LONG RANGE RIFLE PRACTICE.

By A. G. HOLCOMBE.

RIFLE practice at long range is accompanied by an irksome tax on the mind, to relieve which any device is welcome.

It is absolutely necessary to carefully clean the rifle after each shot; to watch the light and calculate the strength and direction of the wind, and note the effect it will have on the ball.

The adjustment of the sights under the same atmospheric conditions varies with the distance to be shot over.

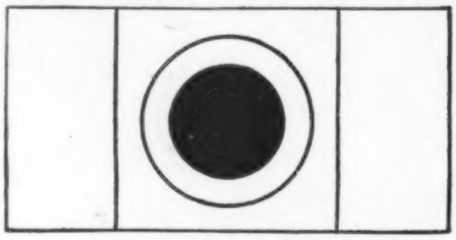
To relieve the mind and simplify calculation, I formulated the diagrams published herewith and pasted them in the front page of my score book. By the use of them I was enabled to make some remarkably good scores after very little practice, and I have no doubt they will prove a valuable aid to others.

The regulation targets for long range shooting are six feet in height and twelve feet broad. A square six feet on the sides occupies the middle. Inside this square is the center ring, four and one-half feet across, with its bull's eye three feet in diameter. The space, three feet by six, on either side of the square is called the outer.

The distance to be shot over for this target is five hundred, eight hundred, nine hundred and one thousand yards.

The rifle is provided with front and rear sights, which are (when the rear sight is on the heel of the rifle) about four feet apart, the front sight being attached to the movable wind gage. The scale by which the wind gage is regulated is divided by lines one-fortieth of an inch apart. The rear sight of the rifle is a sliding eyepiece on the Vernier scale for elevation, the points representing the one one-hundredth part of an inch.

To lay out a diagram for the one thousand yard range (or any other distance), a drawing is first to be made of the target, on a scale say of three-eighths of an inch to the foot. On this diagram two heavy black



THE STANDARD TARGET.

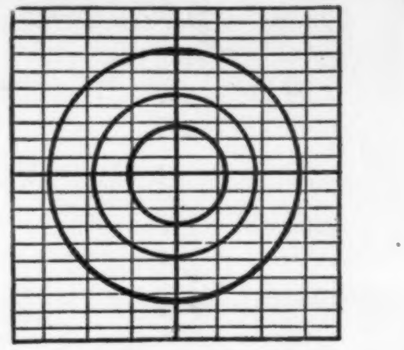
lines are to be drawn, one a perpendicular line passing through the center of the bull's eye from top to bottom of the target and the other a horizontal line passing through the center of the bull's eye and extending to the sides of the target. These lines are the starting points from which to count, right or left from the perpendicular line, for the points on the wind gage, and above and below the horizontal line for the point of elevation, the entire target being divided into spaces by fine red lines, those for the elevation and wind gage being calculated separately.

To lay out on the one thousand yard range diagram the spaces for the elevation, the distance between the butts and the target, i. e., three thousand feet, is to be taken, and divided by the distance between the front and rear sights on the rifle, which we will assume to be four feet. This gives 750 parts. This sum, multiplied by one space of the rear sight, namely, one one-hundredth of an inch, gives 7·5 inches for the height of each space on the target, which, when reduced to scale and set off on the diagram above and below the horizontal line, give four spaces on each side of it, with part of a space remaining above and below.

To lay out on the same one thousand yard diagram the spaces for the wind gage the same rule is to be followed. The three thousand feet divided by four gives 750 parts, which multiplied by one-fortieth of an inch—one space on the wind gage—gives eighteen and three-fourths inches for each of the spaces on the target. These spaces reduced to scale are set off right and left from the perpendicular line running through the center of the diagram, three of them on each side of it and part of a space remaining on either outer side. The diagram, which is now completed, may be pasted in the score book.

If when shooting over the one thousand yard range the rifleman should see that his ball has struck on the extreme upper right hand corner of the target, he could, by referring to his diagram and counting on it the number of spaces between the horizontal line and where his shot struck, see that his rear sight would have to be lowered five points to bring him level with the center of the bull's eye; and his wind gage (the wind and other conditions remaining the same as at the time of the previous shot) would have to be moved four points to the right to bring him in line with the bull's eye center.

To lay out on the diagram the elevation spaces for the midrange or 500 yard target, the same rule must be



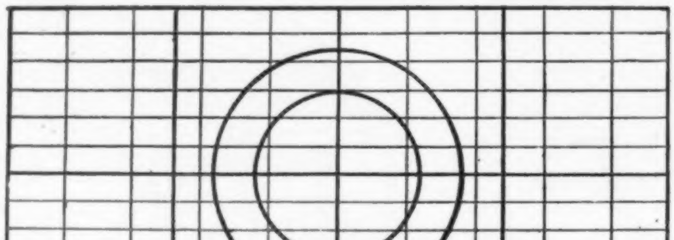
500 YARD DIAGRAM.

followed, the size of the target being six feet by six, with a 22 inch bull's eye.

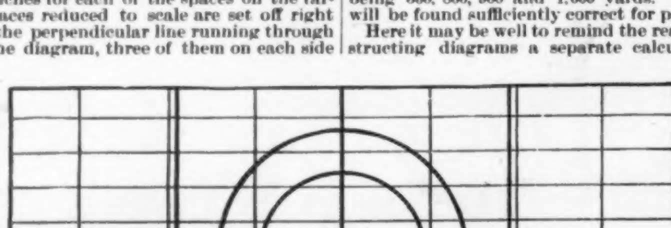
The distance, 1,500 feet, is divided by 4, and this sum, 375, multiplied by $\frac{1}{100}$ of an inch, gives $3\frac{3}{4}$ inches for each space on the target, and this when reduced to scale gives on the diagram nine spaces and part of a space above the horizontal line, and nine spaces and part of a space below it. To lay out on the same diagram the spaces for the wind gage, the 1,500 feet is divided by 4, giving the same 375; this multiplied by $\frac{1}{40}$ of an inch gives $9\frac{375}{1000}$ inches for the target spaces, which, when reduced to scale on the diagram, gives three spaces and part of a space for each side of the perpendicular line.

By following the same rule in laying out the spaces on the 800 yard diagram, for the elevation, the distance 2,400 feet is divided by 4, which gives 600, this multiplied by 0·01 of an inch gives 6 inches. In each of the 3 feet (36 inches) between the horizontal line and the upper and lower edges of the target there will be six equal spaces of 6 inches each. To lay out on this 800 yard diagram the spaces for the wind gage, the 2,400 feet, divided by 4, gives 600. This multiplied by $\frac{1}{40}$ gives target spaces of 15 inches each. These when reduced to scale give 4 spaces and $\frac{8}{15}$ of a space on either side of the perpendicular center line of the diagram. We present with this the diagrams for the 500, 800 and 1,000 yard ranges, drawn to a scale of three-eighths of an inch to the foot. The distances usually shot over being 500, 800, 900 and 1,000 yards. These diagrams will be found sufficiently correct for practical use.

Here it may be well to remind the reader that in constructing diagrams a separate calculation must be made for the different distances shot over, and for the distance the sights on the rifle are apart, also the number of spaces to the inch that the scales of the sights are graduated to. The rule is this: Divide the distance between the butts and the target by the distance between the front and rear sights on the rifle, and multiply the quotient by the distance represented by one point on the scale of the movable sights. This gives the size of the space on the target covered by one



800 YARD DIAGRAM.



1,000 YARD DIAGRAM.

space of the gage. This is then to be reduced to the scale adopted for the diagram.—The Amateur Sportsman.

THE RELATION OF ENGINEERING TO ECONOMICS.*

By WILLIAM KENT.

IN the first page of Mr. J. R. McCullough's "Introductory Discourse" (published in 1828) to his edition of Dr. Adam Smith's great work, "An Inquiry into the Nature and Causes of the Wealth of Nations," he gives one of the best definitions we have of the science of political economy. "Its object," he says, "is to point out the means by which the industry of man may be rendered most productive of those necessaries, comforts and enjoyments which constitute wealth; to ascertain the proportion in which this wealth is divided among the different classes of the community and the mode in which it may be most advantageously consumed."

The definition of engineering given by Telford and incorporated into the charter of the British Institution of Civil Engineers, is "The art of directing the great sources of power in nature for the use and convenience of man." Rankine says: "The engineer is he who by art and science makes the mechanical properties of matter serve the ends of man."

Mr. George S. Morison, president of the American Society of Civil Engineers, in his address at the convention of the society in June of this year, says:

"Every engineering work is built for a special ulterior end; it is a tool to accomplish some specific purpose. Engine is but another name for tool. The highest development of a tool is an engine which manufactures power."

Comparing the above definitions of political economy and of engineering, we find they are closely related. Political economy, according to McCullough, points out the means by which the industry of man may be rendered most productive of wealth. If we asked the merest tyro in knowledge of human industry by what means industry might be rendered most productive, he would naturally answer "By the use of tools." The engineer is the tool builder. His best work is the building of an engine which manufactures power, makes industry most productive and manufactures commodities which are the elements of wealth. Political economy, which points out the means by which industry may be made most productive, should, therefore, point out tools and engines. But, strange to say, the writers on political economy have almost entirely neglected to point out those means. Their "dismal science," as it is called, generally points out everything but tools and engines. It treats of buying and selling, of supply and demand, of rents, interest and wages, of tariffs, of money and currency, of land values, taxes, and what not; but, with rare exceptions, does not mention engineering, which is the most potent force in the economics of the nineteenth century.

Adam Smith, the first great English writer on political economy, writing in 1776, when he was, of course, not to be blamed for knowing nothing of the engineering of this century, said: "The greatest improvement in the productive power of labor, and the greater part of the skill, dexterity and judgment with which it is anywhere directed or applied, seem to have been the effects of the division of labor." He gives a famous instance of division of labor in the manufacture of pins. One man, he said, might with difficulty make one pin a day, and certainly could not make twenty. But as the manufacture was carried on in his day, by division of labor one man draws out the wire, another straightens it, a third cuts it, a fourth points it, a fifth grinds it at the top for receiving the head, and so on, dividing the labor up among ten men and eighteen different operations.

Those ten men thus made between them 48,000 pins per day. Most writers on political economy have followed Adam Smith, and given division of labor the credit for making the greatest improvement in production, and neglected the still more important improvement, the introduction of machinery, by which the labor of the ten men was all done by a machine with one man tending it. But I find that Robert Ellis Thompson in his work on political economy (1875) mentions the case of the pin industry in its modern phase. He says: "An inventive mechanic has put together a machine that only needs to be fed with wire, well oiled and supplied with steam power, to turn out complete pins, sorts them and even thrusts them into the papers in the right numbers and in straight rows."

The example of the pin industry may be taken as representative of what has taken place in every branch of productive industry. By the use of the steam engine and of other machinery the productive power of human labor has been increased a thousandfold, and engineering thus becomes the most important force which has caused an industrial and economic revolution throughout the civilized world, and the one subject of all others which should be discussed by a political economist.

Political economy being broadly the science of wealth, and since wealth is property, and property, according to some writers of the socialistic school, is robbery, it may be well to get our bearings here, and see whether wealth is a thing to be desired or not. I quote here the words of Mr. McCullough in his "Introductory Discourse," above mentioned, and without further argument may say that I agree with him entirely.

"The acquisition of wealth is not desirable merely as the means of procuring immediate and direct gratification, but as being indispensably necessary to the advancement of society in civilization and refinement. Without the tranquillity and leisure afforded by the possession of accumulated wealth, those speculative and elegant studies which expand and enlarge our views, purify our taste and lift us higher in the scale of beings, can never be successfully prosecuted. It is certain, indeed, that the comparative barbarism and refinement of nations depend more upon the comparative amount of their wealth than on any other circumstance. It is impossible to name a single nation which has made any distinguished figure either in philosophy or the fine arts without having been at the same time celebrated for its wealth."

Having thus settled the question of the desirability of wealth, let us consider what is the engineer's share in its production. The great forces of nature which the engineer utilizes for the production of wealth are the forces of wind and of running water, and the stored energy of fuel in the forests, peat bogs, coal mines, and gas and oil wells. By far the greatest of these forms of stored energy is that of coal. Let us compare for a moment the work that can be done by a ton of coal with the muscular power of men. One man digging coal from the side of a hill can easily dig two tons, say 4,000 lb. of coal, in a day. Another man running a boiler and engine can burn these same two tons under a boiler, and if the engine is a moderately good non-condensing engine using 3 lb. of coal per indicated horse power per hour, it will develop from the two tons of coal 133 horse power for 10 hours, equivalent to the physical labor that could be done by 1,300 men. Thus a man's labor by means of coal and a steam engine can be multiplied 650 times. But if we use a large high-grade triple expansion, condensing engine, it will require only half as much coal per horse power, and then if we set the engine to work to mine the coal itself, through the agency of mining machinery, and to feed its own coal to the boiler by means of automatic stokers, we see that the effectiveness of man's labor can be still more vastly increased.

Let us consider some of the results which the engineer has been able to accomplish by the utilization of coal.

In my study of the subject of this address, while I have failed to find it properly treated in any of the standard works on political economy to which I have had access, I have found it discussed in a more or less fragmentary manner in writings and addresses of numerous engineers, statisticians and other specialists, and since it is more convenient to quote largely from their writings than to write anything original, I will now trouble you with some quotations.

I first quote from a recent lecture by Mr. Edward Orton, State Geologist of Ohio, before the Ohio Mining Institute:

"All the great applications of the stored power of the world belong to the nineteenth century, and the most important of them belong to the last fifty years. What has been done within this century constitutes by far the most important chapter in the economic history of the race. Fossil power lies at the root and center of this unparalleled advance. In Great Britain alone coal does the work of more than 100,000,000 men. It adds to the wealth of these fortunate islands on this basis.

"The great powers, those that are making over the world, are steam and electricity. The steam engine lies at the bottom of by far the greatest industrial and economic revolution through which the race has ever passed, and steam is now being reinforced by the new motor, from which we justly expect so much.

"We note some further consequences of the discovery and use of fossil power on the large scale. We shall find the most striking characteristics of our day and age, so far as the material side of life is concerned, centering around this one element. What are these characteristics of the nineteenth century? There are no more distinctive features of our time than the two following—viz., the remarkable growth of cities throughout the civilized world and the unparalleled increase of the wealth of men. Both take their rise in coal; both are conditioned by its use in all their phases and stages. All modern manufactures are absolutely dependent on the stored force of coal. Machinery driven by this power is everywhere replacing the skilled labor of the olden time. Cities grow largely by massing the ruder labor that our modern factories can utilize.

"With this growth of cities in the modern world, a group of problems arises, all of which are new and of which we are obliged to work out the solutions. No other problems of equal gravity and urgency confront the statesman, philosopher or philanthropist of our day. All of them have their root in coal."

Mr. John Birkinbine, Past President of the American Institute of Mining Engineers, estimates that if only one per cent. of the consumption of fuel of all kinds in the United States, including coal, wood, oil and gas, were saved, it would be equal to 2,300,000 tons of coal per year. It is the work of the engineer to devise ways and means to accomplish this saving and more.

Mr. Chas. H. Loring, Past President of the American Society of Mechanical Engineers, in his presidential address in 1892 thus spoke of the influence of the steam engine upon civilization:

"The civilizations of antiquity were limited to a few cities, and were based upon a slave labor, the slaves being drained from other places, which were thus doomed to deepening barbarism.

"The disgrace of the ancient civilization was its utter want of humanity. Justice, benevolence and mercy held but little sway; force, fraud and cruelty supplanted them. Nor could anything better be expected of an organization based upon the worst system of slavery that ever shocked the sensibilities of man. As long as human slavery was the origin and support of civilization, the latter had to be brutal, for the stream could not rise higher than its source. Such a civilization, after a rapid culmination, had to decay, and history, though vague, shows its lapse into a barbarism as dark as that from which it had emerged.

"Modern civilization also has at its base a toiling slave, but one differing widely from his predecessor of the ancients. He is without nerves and he does not know fatigue. There is no intermission in his work, and he performs in a small compass more than the labor of nations of human slaves. He is not only vastly stronger, but vastly cheaper than they. He works interminably, and he works at everything; from the finest to the coarsest he is equally applicable. He produces all things in such abundance that man, relieved from the greater part of his servile toil, realizes for the first time his title of Lord of Creation. The products of all the great arts of our civilization, the use of cheap and rapid transportation on land and water, and of printing, density of population everywhere, the instruments of peace and war, the acquisition of knowledge of all kinds, are made the possibility and the possession of all by the labor of this obedient slave, which we call Steam Engine.

"We who were born under this benign influence but vaguely appreciate its value, and rarely recognize our obligations to it; existing civilizations would be impossible without it, and if human ingenuity finds no substitute for it, they will perish with it.

"The steam engine is a machine which has been the prolific parent of other machines. It has caused the invention and construction of the immense plant of ingenious power tools employed in its own fabrication; it has caused the improvement of metallurgy as a science and of the various methods of metal manufacture as an art; it may be said to have created whole branches of important manufacture, and to have been the occasion of the invention of the immense mass of highly diversified machinery by means of which these manufactures are practiced; and, last and greatest, it has stimulated and directed the human intellect as nothing else ever has, and has done more to advance human nature to a higher plane than all which statesmen, generals, monarchs, philosophers, priests and artists have ever accomplished in the vast interval which separates original man from the man of to-day. It has raised man from an animal to something approaching what a great intelligence should be by simply placing in his hands a limitless physical power capable of application in every conceivable direction and to every conceivable purpose."

The value of the invention of Bessemer steel to the human race is discussed as follows in an address by Mr. Abram S. Hewitt in 1890 ("Trans. Amer. Inst. Mining Engineers," Vol. XIX, p. 518):

"The Bessemer invention takes its rank with the great events which have changed the face of society since the middle ages. The invention of printing, the construction of the magnetic compass, the discovery of America and the introduction of the steam engine are the only capital events in modern history which belong to the same category as the Bessemer process. They are all examples of the law of progress, which evolves moral and social results from material development. The face of society has been transformed by these discoveries and inventions.

"Steel is now produced at a cost less than that of common iron. This has led to an enormous extension in its use and to a great reduction in the cost of the machinery which carries on the operations of society. The effect has been most marked in three particulars: First, the cost of constructing railways has been so greatly lessened as to permit of their extension into sparsely inhabited regions, and the consequent occupation of distant territory otherwise beyond the reach of settlement; second, the cost of transportation has been reduced to so low a point as to bring into the markets of the world crude products which formerly would not bear removal, and were thus excluded from the exchanges of commerce; third, the practical result of these two causes has been to reduce the value of food products throughout the civilized world, and, inasmuch as cheap food is the basis of all industrial development and the necessary condition for the amelioration of humanity, the present generation has witnessed a general rise in the wages of labor, accompanied by a fall in price of the food which it consumes. . . . These are material results, but they are accompanied with the slow but sure elevation of the great mass of society to a higher plane of intelligence and aspiration."

The increase of working power of the United States is thus shown by Mr. M. G. Mulhall, the great statistician, in the North American Review for June, 1895. The working power of an able-bodied male adult is 300 foot tons daily; that of a horse, 3,000; and of steam horse power, 4,000. On this basis the working power of the United States was at various dates approximately as follows, in millions of foot tons daily:

Year.	Hand.	Horse.	Steam.	Total.	Foot tons daily per inhabitant.
1820	758	3,300	240	4.298	446
1840	1,406	12,900	3,040	17.346	1,020
1860	2,805	22,200	14,000	39,005	1,240
1880	4,450	36,600	36,340	77,390	1,545
1895	6,400	55,200	67,700	129,300	1,940
Great Britain, 1895	3,210	6,100	46,800	56,110	1,470
Germany, 1895	4,280	11,500	29,800	45,580	902
France, 1895	3,380	9,600	21,600	34,580	910
Austria, 1895	3,410	9,900	9,200	22,510	560

Notice from this table how vastly the power of man is increased by the use of the steam engine, and in the United States how great was the increase in the last 15 years.

The wealth of the American people, says Mr. Mulhall, surpasses that of any other nation past or present. The physical and mechanical power which has enabled a community of wood cutters and farmers to become, in less than 100 years, the greatest nation in the world, is the aggregate of the strong arms of men and women, aided by horse power, machinery and steam power applied to the useful arts and services of everyday life. The accumulation of wealth in the United States averages $7,000,000 daily.

The increase of wealth in the United States is shown as follows, according to Mulhall:

Year.	Total wealth, millions of dollars.	Wealth per capita.
1820	1,960	$205
1840	3,910	230
1860	16,160	514
1880	43,642	870
1890	65,037	1,039

Wealth per capita in different countries in 1890:

Great Britain	$1,260
France	1,130
Holland	1,069
United States	1,039
Belgium	840
Germany	780
Sweden	680
Italy	480
Austria	475

Average yearly wages per operative in the United States:

1860	$280
1870	302
1880	347
1890	495

* Vice-presidential address delivered before Section D, Mechanical Science and Engineering, of the American Association for Advancement of Science, at Springfield, Mass., August 29, 1895.

Rural or agricultural wealth in the United States has quadrupled in 40 years, while urban wealth has multiplied sixteenfold.

	Millions of dollars. Urban.	Rural.	Total.	Per cent. of total. Urban.	Rural.
1850	3,169	3,965	7,136	44·4	55·6
1860	8,180	7,980	16,160	50·6	49·4
1870	15,155	8,900	24,055	63·0	37·0
1880	31,538	12,104	43,642	72·2	27·8
1890	49,065	15,982	65,037	75·4	24·6

During the last 20 years the increment of rural wealth has been almost uniform at $47 per head per annum of the number of rural workers. In urban workers the accumulation averaged $83 per annum, which suffices to explain the influx of population into towns and cities.

The increased productiveness of the farmer, due to his use of machinery, is shown as follows:

"An ordinary farm hand in the United States raises as much grain as three in England, four in France, five in Germany and six in Austria, which shows what an enormous waste of labor occurs in Europe because farmers are not possessed of the same mechanical appliances as in the United States.

"In the United States one man can feed 250, whereas in Europe one man feeds only 30 persons. Nor can we hope for a better state of things in Europe soon. So dense is the ignorance of most men, even among the ignorant classes, that they are convinced that all labor-saving appliances are an evil, and that the more persons there are employed to do any given work the better."

During a visit to Germany three months ago I learned of an instance of this ignorance among the laboring classes. My traveling companion saw three men cutting grass on a lawn with ordinary scythes and sickles. "Why don't you use a lawn mower?" said he, "then one man could do as much as three." "Don't talk to us about lawn mowers," said one of the men, "it is all we can do now to find work enough to earn our bread. If we had a lawn mower two of us would starve." They did not think that if their employer saved the wages of two men, the money would burn a hole in his pocket until he either employed it for some useful purpose, by giving employment to either the same two men or two others, or loaned it to some one who would employ it.

In the United States however, the old-time opposition to the introduction of labor-saving machinery as a harm to the laboring man, throwing him out of employment, has now almost died out among reasoning men, and it is generally acknowledged by men who have studied the subject that the steam engine and labor-saving machinery in general are the chief agents of the civilization of the latter half of the nineteenth century, and that they have increased the productiveness of man's labor, increased his wages, shortened his hours of labor, cheapened his food and clothing, and given the average man comforts and luxuries which a century ago not even kings would have commanded.

Mulhall's "Dictionary of Statistics," 1892, gives the following facts concerning the agriculture of the world. Capital and product have more than doubled since 1840, but the number of hands has not risen 50 per cent.

AGRICULTURAL CAPITAL OF THE WORLD.

Millions of Dollars.

	Land.	Cattle.	Sundries.	Total.
1840........	35,475	4,970	4,735	45,180
1860........	59,310	7,810	7,495	74,615
1887........	88,870	13,505	12,645	115,030

AGRICULTURAL CAPITAL OF THE UNITED STATES.

Millions of Dollars.

	Land.	Cattle.	Sundries.	Total.
1840	2,000	480	500	2,980
1860........	6,910	1,130	1,185	9,225
1887........	12,800	2,505	3,175	18,480

In the United States 9,000,000 hands raise nearly half as much grain as 66,000,000 hands in Europe. Thus it appears that for want of implements and of proper machinery there is a waste of labor equal to 48,000,000 of peasants.

The census returns of the manufactures of the United States, 1880 and 1890, show the following:

	1880.	1890.	Increase, per cent.
No. of establishments reporting..	253,502	322,624	27·27
Capital..............	$2,780,766,895	$6,138,716,604	120·76
Av. no. of employes	2,700,732	4,476,094	65·74
Total wages........	$939,462,252	$2,171,356,919	131·13
Cost of materials used............	3,395,925,123	5,018,277,603	47·77
Value of products.	5,349,191,458	9,054,191,458	69·27

Vast economic changes throughout the world have recently taken place as the result of the development of engineering. Mr. Edgerton R. Williams in his article on "Thirty Years in the Grain Trade" (North American Review, July, 1895), says:

"In 1860, 97 per cent. of England's population, say $18\frac{1}{2}$ out of 19 millions, were fed on English grown wheat. In 1890, with a population of 25 millions, only 5 millions were supplied with English wheat, a falling off of 77 per cent. The decrease in wheat acreage in 40 years, from 1846 to 1886, was nearly 66 per cent."

The tendency of population from the country to the cities is a consequence of the increased production of manufactures and of the decrease in the percentage of the total population required to produce the food of the world. This tendency in the United States is shown in the following census figures:

Urban population per cent. of total.					
United States..	1850	1860	1870	1880	1890
Per cent.......	12·49	16·13	20·93	22·57	29·12

In the northern central division of the United States, in the past 10 years, the urban element has nearly doubled, while the total population has increased only 25·78 per cent. The increase in urban population is confined mainly to a few large cities.

The completion of the Trans-Siberian Railroad and the extension of railroads in India and in the Argentine Republic will probably before long make Europe independent of the grain crop of America. Mr. Worthington C. Ford, Chief of the United States Bureau of Statistics, in the North American Review for August, says:

"It is now the Argentine Republic which appears to have an almost unlimited power to grow and export wheat in defiance of any competition."

The perfection of refrigerating machines—an engineering triumph—makes it now possible for Europe to receive its supply of meat from Australia and from the Argentine Republic, as well as from the United States. The introduction of modern cotton machinery into Japan and India threatens the cotton trade of England with exclusion from the markets of Asia, one of England's greatest present resources. In Australia, according to Mr. Ford, the ranchmen are successfully overcoming one of the most serious obstacles to the extension of sheep raising, by sinking artesian wells and making pools or dams to retain the water for their stock—another example of the application of engineering in using nature's stored forces to overcome the resistance of nature. There thus appears to be no limit to the economic changes throughout the world which may yet be made by the use of engineering appliances.

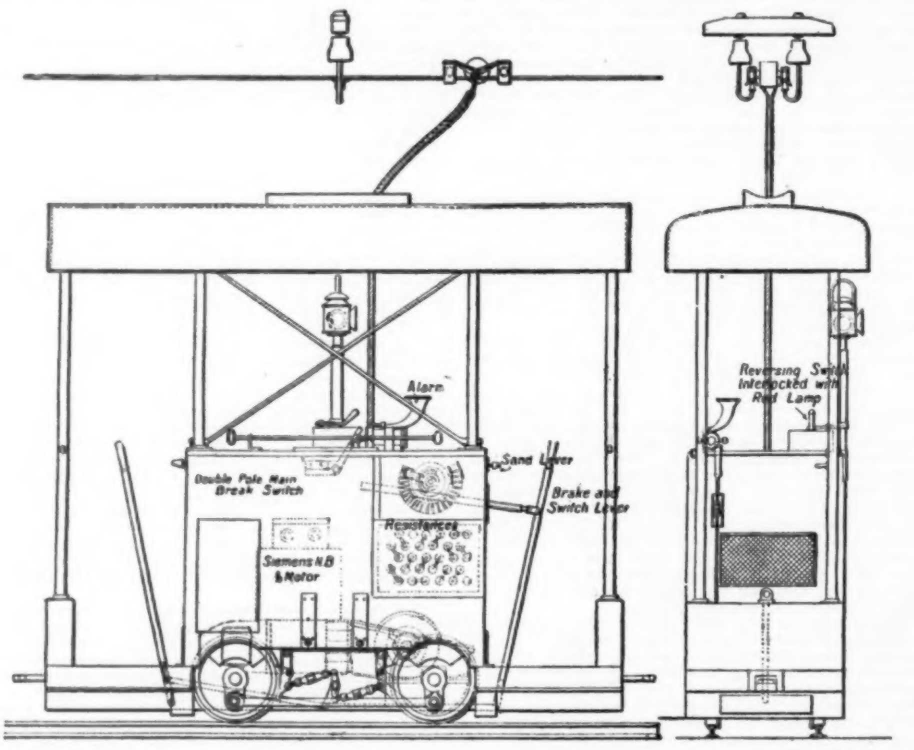
(To be continued.)

[FROM THE ENGINEER, LONDON.]

THE WATERLOO AND CITY ELECTRICAL UNDERGROUND RAILWAY, LONDON.*

THE contract for the construction of the line from Cross Street—which is close to Waterloo station—to the City, including the City terminus under the roadway at the top of Queen Victoria Street, was let in June, 1894, to Messrs. John Mowlem & Company.

This firm decided to do the whole of the excavation from a staging in the river; and proceeded at once to drive piles near the Surrey shore, just below low water mark, as shown on Fig. 4, page 16416, last week.



"THE ENGINEER" SWAIN ENG

Figs. 14 and 15—ELECTRIC CONTRACTOR'S LOCOMOTIVE

THE WATERLOO AND CITY ELECTRICAL UNDERGROUND RAILWAY, LONDON.

The distance of the center line of the railway from Blackfriars Bridge, at the point where the shafts were sunk, is about 500 ft. The staging is 325 ft. long by 50 ft. wide; the first pile was driven on June 20, 1894, and it was finished in November. The connection with the shore is by means of a foot bridge from 15 Upper Ground Street; but all spoil is removed, and the cast iron rings, and all other materials, are brought to the site by water. The large stage in the river not only serves as a starting point for the shafts, but carries the engines, dynamos, air compressors, cranes, offices and stores.

In August, 1894, the sinking of the shafts was commenced. These are cast iron cylinders 16 ft. internal diameter, and they were sunk into the bed of the river till they had entered the clay to a depth of 13 ft.

When the contents of these cylinders had been excavated, the sinking of the shafts was continued. This lower part was lined with brickwork, the first 10 ft. being 1 ft. 6 in. thick, followed by 17 ft. of 2 ft. 3 in. thick, which reached to the bottom of the tunnels.

The upper part of the brick work is circular, like the cylinder, but the section is gradually changed, so that at the bottom the shafts have two flat sides, at right angles to the axis of the tunnels, the section being very nearly a square with rounded ends. This part of the work was finished early in October, and the shields for driving the four headings were then lowered in pieces and put together at the bottom of the shaft.

On November 26, the contractors started on the up tunnel toward the City, and on December 10 the other side of the same tunnel was commenced. Work on the City end of the down tunnel began on January 16, and toward Waterloo on the 28th.

The Greathead shield has often been mentioned in the Engineer, but it has never been fully described nor illustrated.* Figs. 11, 12 and 13 show front view, section and back view of the shields used between the shafts and the City. The two for the up and down tunnels, between the shafts and the Waterloo end, are identical, except that they are $7\frac{1}{4}$ in. greater in diameter than the one shown in illustration. The front of the shield is formed by a heavy cast iron ring, made in four segments, with flanges for bolting together. A steel cutter, 1 in. thick, in eighteen segments and forming a continuous conical ring, is secured to the casting by set screws and projects $2\frac{3}{4}$ in. in front of it. At the back of the casting is a $\frac{3}{4}$ in. wrought iron diaphragm, in the middle of which there is a rectangular opening of 6 ft. 6 in. high by 5 ft. 6 in. wide. This diaphragm is stiffened by 4 in. by $\frac{3}{4}$ in. strips riveted to it back and front, as well as by two 6 in. by 3 in. by $\frac{3}{8}$ in. channel irons at the back.

Behind the diaphragm is another cast iron ring, in seven segments, each of which carries the steel cylinder of a hydraulic ram. These are 7 in. diameter by 22 in. stroke. The back ends of the piston rods are let into steel castings, which bear against the last finished ring of the tunnel. By means of a circular tube from the hydraulic main, the same pressure can be exerted by all the rams; or by working some of the presses and stopping others, the direction of the shield can be varied as may be desired. When the pistons of the

* Our contemporary evidently has been misinformed as to the nature of the so-called "Greathead System." Mr. Greathead, we believe, has never claimed the invention of shield excavation or the hydraulic shield, or the cast iron plate lining for tunnels, or the use of compressed air in tunnel excavations. Taking these away, all that remains to the "Greathead System" is his mode of grouting, for which he obtained patents. The hydraulic shield is an American invention, designed by Mr. A. E. Beach, of the SCIENTIFIC AMERICAN, New York, and was employed by him in 1869 in constructing a railway tunnel under Broadway, New York, cast iron plates being used in walling the tunnel. The same year (1869) Mr. Greathead was employed under the late Peter Barlow in constructing the 8 ft. Tower subway under the Thames, London, for which Mr. Barlow used a barrel shield, worked with separate screws turned by hand. While Mr. Barlow, and his assistant Mr. Greathead, were tunneling under the Thames in 1869 with a separate screw shield, Beach was tunneling under Broadway, New York, with his hydraulic shield.

In the Beach Hydraulic Shield, a series of powerful hydraulic rams are used to drive the shield ahead, the rams being arranged around the rear edge of the shield and connected with the pumps, each ram having its own cock, so that the driving pressure may be applied instantly and simultaneously to all the rams, or to such portion of them as may be desired.

By means of this arrangement of hydraulic rams the engineer is enabled to govern the movement of the shield with the utmost precision, making it to ascend or descend in the earth, according to the grade required, or travel on curves of the desired radius.

Since the construction of the Broadway tunnel the Beach Hydraulic Shield has been employed on a number of important engineering works, with much success, and it is now generally recognized as an important adjunct in the execution of various classes of underground tunnels.

Greathead made use of the Beach Hydraulic Shields in building (1886-9) the City and South London tunnels. He is also using them on the tunnels of the Waterloo and City Electrical Underground Railway now in process of construction. The Beach Hydraulic Shields were also used in the construction of the great railway tunnel, 21 ft. diameter, under the St. Clair River (1890), between Port Huron, Mich., and Sarnia, Canada, also in the Hudson River tunnel, New York, also the new East River gas tunnel, under the East River, 71st Street, New York. For the three tunnels under the Clyde at Glasgow and the Edinburgh tunnels, both lately completed, the Beach machines were employed. The most remarkable work on which the Beach Hydraulic Shields have been used is the Blackwall tunnel, which is 27 ft. diameter, now in process of construction under the Thames River, London.

In a paper on tunnel construction, by Mr. Maurice Fitzmaurice, M. Inst. C.E., resident engineer of the Blackwall tunnel, read before the British Association, 1894, he shows that Brunel had thoughts of using hydraulic jacks in connection with shields as far back as 1818. But inasmuch as he subsequently used separate screws it is evident he had no idea of a shield provided with connected rams for instantly controlling the pressure upon any part of the shield, at the will of the engineer. Nor is it likely Barlow or Greathead, fifty years later, would have adopted separate screws in the Tower subway if anything contained in Brunel's patent, of 1818, had suggested to their minds such a structure as the Beach Hydraulic Shield.

Prior to its employment on the Broadway tunnel, in 1869, no such machine was known to engineers. Since that date it may be said to have come into general use.

The employment of compressed air in tunnels for holding up the roof and heading was also first brought into use in this country. It is the invention of Mr. Dewitt C. Haskin, of New York City, and was employed by him in the construction of his tunnel under the Hudson River from 1874.

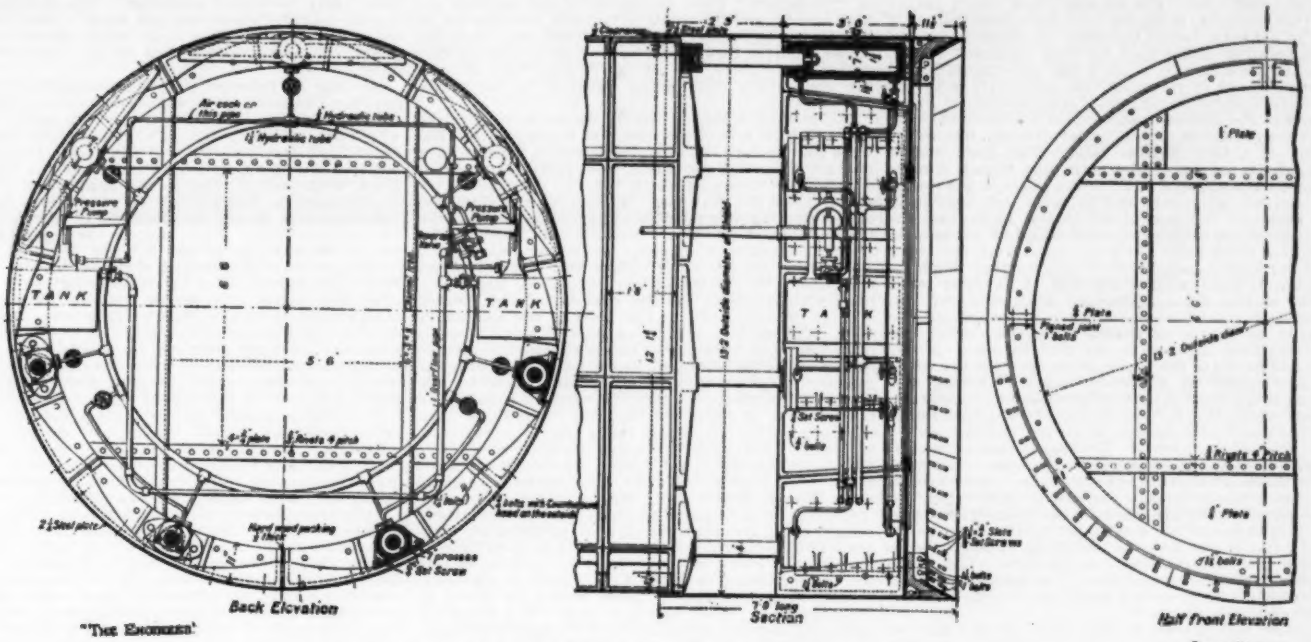
Greathead made use of it in 1886 in the City and South London tunnels, and it is now generally employed by engineers in tunnel work.

* Continued from SUPPLEMENT, No. 1027, page 16416.

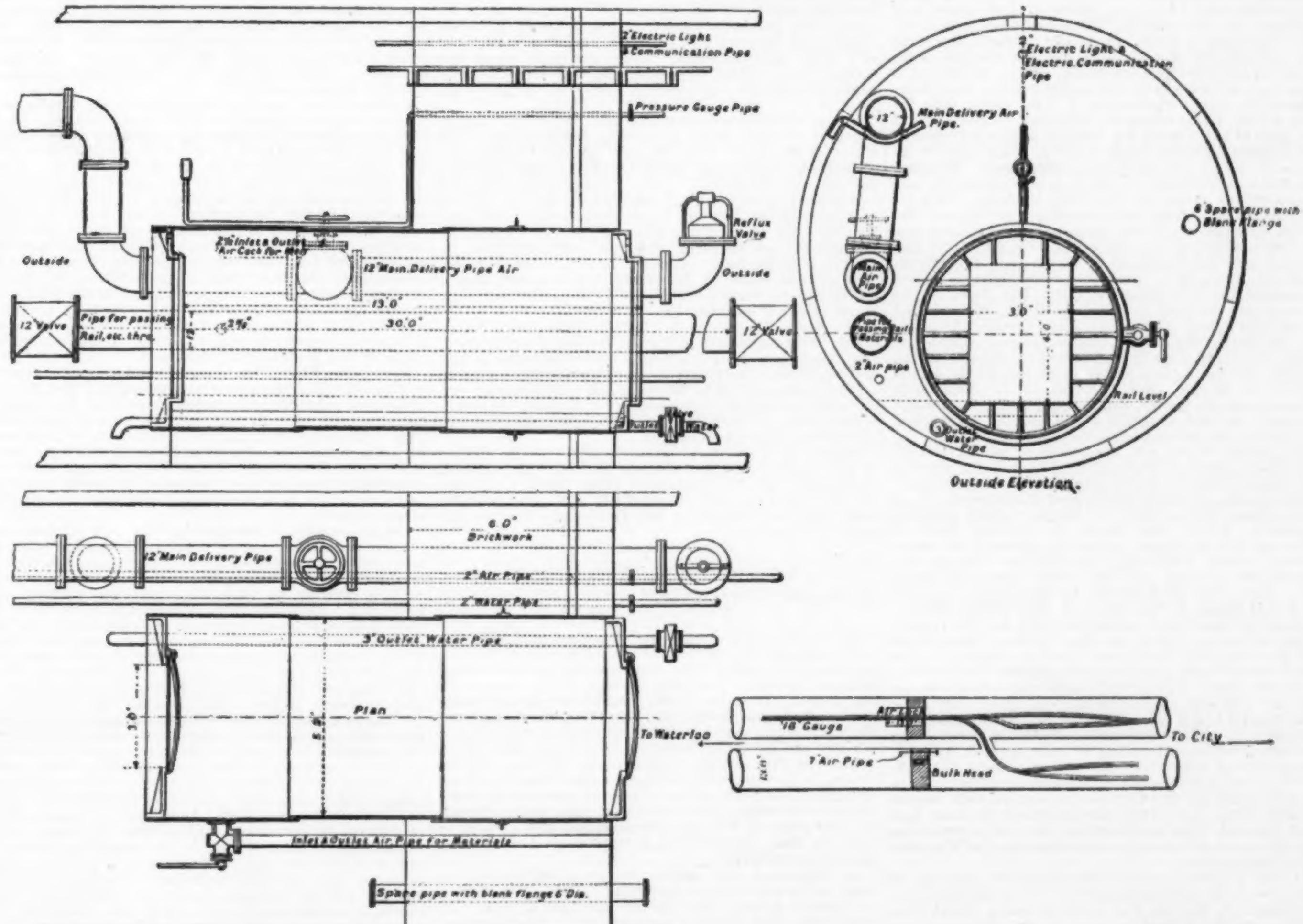
rams are out to their fullest extent, they are protected from any dirt or stones that might otherwise fall on them by a cylinder formed of two ¼ in. steel plates which surround the shield and extend backward over the finished portion of the tube; ⅜ in. clearance being left between the outer side of the cast iron ring and the inner side of the steel plate.

Whether working under compressed air or not, a heading is always dug out and timbered in advance of the shield—see illustration page 16414. The size of this and bolted up. These castings are made by Messrs. Head, Wrightson & Company. They are moulded by special machinery designed for the purpose, and all segments of the same sized rings are interchangeable. The weight of each complete ring is 1·81 tons for the larger size and 1·73 for the smaller. As a rule, whether working under compressed air or not, two complete rings can be put in per shift; occasionally three have been done by a day and three by the following night shift, which gives a progress of 10 ft. in the twenty- sand are mixed with water, and then, while a handle is continually turned, to keep the mixture homogeneous, air at a pressure of 50 lb. to the square inch is admitted and the grouting is thus forced through a hose into the vacant space behind the ring, which it completely fills.

It may here be remarked that Mr. Greathead's invention, as used on the City and South London Railway, and on numbers of other tunnels which have been constructed since, consists in the combination of



Figs. 11, 12, and 13—ELEVATION AND SECTIONS OF THE GREATHEAD SHIELD



Figs. 16, 17, and 18—THE AIR LOCK

Fig. 19—PLAN OF AIR LOCK AND BULKHEAD

THE WATERLOO AND CITY ELECTRICAL UNDERGROUND RAILWAY, LONDON.

heading varies according to the nature of the ground; while in the clay, and before using compressed air, it is 7 ft. high by 5 ft. wide in the clear. The timbering for this is composed of 4 in. by 11 in. head trees, 3 in. by 11 in. side trees, and hard wood foot blocks 9 in. by 9 in. by 3 in.

The shield, except when a change of direction is necessary, is pushed forward equally by all the hydraulic presses for 20 in. The seven segments and key piece, which form a complete ring, are then lifted into place four hours, but this is exceptional. The number of men in heading is twenty, and when compressed air is used, there are the lock keepers in addition. The total number of men employed on the works at present is about 200.

Directly a ring is in place, grouting, composed of three parts of blue lias lime to one of sand, is injected through holes left in the center of each plate by means of a patent grouting apparatus, known as a "bougie." This consists of an iron drum, in which the lime and cast iron lining, shield excavation, compressed air, and compressed air grouting.*

When working near the shafts, the spoil was shoveled into skips which stood on low platform wagons, pushed by hand to the shafts, hoisted by steam cranes to the platform, and emptied into barges—see drawing, page 16414, last week. As the tunnels advanced, another form of skip, without handles, was used, as

* See foot note on page 16426.

those shown in the drawing could not pass through the air locks. The haulage is now done by means of electric locomotives. These have been made by Messrs. Siemens Brothers & Company, and were especially designed for this work by that firm. Two are in use at present, and a third is on order. The current is supplied from the dynamos at the top of the stage. Figs. 14 and 15 show side and end elevation of one of these locomotives. The line is worked on what is known as the "double trolley" system, and with an effective pressure or difference of potential of about two hundred volts. The wooden block which carries the two insulators is bolted to a transverse flange of the tunnel tube, two of the holes for bolting the sections together being used for that purpose. On account of the difficulty which it was anticipated would be experienced in reversing the locomotive with the ordinary under-running trolley construction, in consequence of the limited head room, it was decided to use an over-running two-track trolley carriage, hauled by means of a twin flexible cable. This arrangement also permits the use of the main line trolley wire at sidings, "the angle of pull" of the cable on the trolley carriage not being sufficient to cause any trouble in this respect. The gage of the line is 18 in., and the locomotives are designed to haul a load of five tons at a speed of seven miles per hour on the level, and three miles per hour on a gradient of one in sixty. Each locomotive is fitted with a Siemens H. B. eight tenth motor, carried upon a strongly built wrought iron frame, and geared to the driving wheels, which are coupled by means of double reduction—bevel and spur—gearing, inclosed in an oiltight case. A rod attached to one of the brake levers operates the starting and regulating switch by means of a rack and pinion, so adjusted that it is impossible to apply the brakes while the current is on. This arrangement also enables the locomotive to be driven from either end with equal facility. The regulation is accomplished by means of resistance steps in the usual way. There is also a reversing switch, a main current emergency switch, and fuses of the double pole type. To the reversing switch is geared a lamp, which turns so that it always exhibits a red light in the direction in which the locomotive is traveling. Instead of a whistle, there is a pneumatic signal horn. The whole is covered by a galvanized sheet iron canopy, as shown on drawing, and there is a sand box, which is found useful on the gradients.

The air lock, shown in Figs. 16 to 18, and also on pages 16414 and 16415, last week, has been specially designed by Messrs. Mowlem & Company for this work. It consists of a wrought iron cylinder 5 ft. 9 in. internal diameter and 13 ft. long, made of ½ in. plate, and stiffened with T iron rings. A wall of brick in cement, 6 ft. 2 in. thick, is built across the tunnel; and into this wall not only the air lock but the various pipes shown on the drawings are built. These consist of a 12 in. pipe for materials, a 12 in. air main, a 2 in. compressed air pipe for grouting, a 2 in. water pipe for ditto, a 3 in. water outlet for drainage, if necessary, a 2 in. pipe at the top for the electric pump, telephones, and electric lighting wires; and a spare pipe 6 in. diameter, with a blank flange at either end. This last pipe has been provided as an extra precaution in case of an accident to any of the other conduits. The air main is carried along the completed portion of the tunnel near the top, being supported by wrought iron brackets bolted to the flanges. The tube for materials has a clear length of 30 ft. between the valves. This was necessary in order that rails might be passed through it for extending the line. The doors of the air lock are of cast iron, 1¼ in. thick, stiffened all round with webs. They both open toward the pressure, so that they must remain closed while the pressure is being equalized. Valves for regulating the pressure can be worked either from the inside or the out; when people pass through it is necessarily worked from the inside, and is so set that the change must take at least a minute and a quarter; but when only trucks are being passed it is more rapid.

By a clause in the act, the Waterloo and City Railway, when passing under the Metropolitan District Railway, or within thirty yards of it, must do such underpinning, or make such use of compressed air, as the engineer of the District Railway shall consider necessary. Under this clause the District Railway called on the engineers to use compressed air when passing under their line, between the Temple and Blackfriars stations, and for thirty yards on either side. This extended from the Embankment, opposite the Royal Hotel, to the center of New Bridge Street. As it is not likely that compressed air will be needed at any other portion of the line between Blackfriars and the City, Mr. Galbraith made a suggestion by which one air lock would be sufficient for both the up and down lines. The arrangement made is shown on Fig. 19. The air lock was in the up tunnel only; the down tunnel being closed by a solid brick bulkhead, pierced only by the air main. Parts of three rings were removed from the sides of both tunnels, and between these a temporary opening was built, through which a line of rails was put down connecting those in the two tunnels. By this means one air lock served for both lines, and when the thirty yards limit had been reached, bulkheads and air lock were removed, and the latter will shortly be utilized for the Waterloo end of the up line.

At the Waterloo end of the down line the use of compressed air was commenced at the same date as at the other end, May 22, the pressure being about 7 lb. or 8 lb. As this tunnel is nearer to the water-bearing ballast which covers the clay than any of the others, and will be the first to enter it, timbering was at once commenced. The heading, which is kept two rings in front of the rest of the excavation, is 6 ft. by 3 ft. in the clear, the top of the head tree being level with the top of the shield. Small piles are driven ahead horizontally into the clay. From the center downward there are poling boards, 1½ in. thick, for 4 ft. 6 in. on each side. These are carried by leg boards against the face, the tops being cut to the sweep of the shield. The leg boards stand on an 11 in. by 4 in. waling, which is strutted against the front of the shield, at a height of 6 in. below the top of the door. When this part of the timbering is in place the excavation is continued below it for about 4 ft., when a second waling is placed across and strutted against the front of the shield as before. Poling boards are then placed from upper to lower waling. Finally, the excavation is continued down to the level of the bottom of the shield. In order to be able to remove the struts between the shield and the walings, which serve to keep the latter in their places, two upright timbers, 11 in. by 4 in., known on the works as "soldiers," are placed against the walings, and a beam 10 in. by 10 in. is placed right across the tunnel, three rings back, and is wedged firmly against the sides. From this cross beam two raking struts are placed against the center of the soldiers and wedged up tight. The temporary struts, or "stretchers," from the shield to the walings are then struck, and the shield is pumped forward for 20 in. One ring is inserted and grouted, and then the shield is moved forward for another 20 in., and another ring is put in place. As soon as this has been grouted the excavation and poling proceed as before for another 40 in.

The method of setting out the curves is by means of rods on either side of the tube. It was mentioned last week that though the separate segments which form a ring are planed at the joints, each complete ring has a packing of creosoted wood, ⅜ in. to ½ in. thick, between it and the next one. By varying the thickness of this packing, it is possible to direct the course of the tunnel as may be desired. On a five-chain curve radial segments have been necessary, as the sections are 1 ft. $8\frac{11}{16}$ in. wide on the outer radius and 1 ft. $7\frac{11}{16}$ in. on the inner. The tubes, when completed, are to be lined with concrete; and this part of the work is being done at present down to the level of the temporary rails. The mixture used is one part of cement to six of ballast; but for filling in the key piece, the proportion of cement is increased, and sand is used with fine ballast. A special apparatus has been made for filling these top pieces. A box with wooden sides, and a false bottom of sheet iron, is hung by stirrups from the bolts. This box, before being placed in position, has been filled with the exact amount of concrete which one key piece will hold. Two rollers, worked by a lever handle, raise the false bottom, so as to cause the concrete to enter the key piece. The plate is held up by pins passed through the stirrups; then, wedges being removed, the sides of the boxes are withdrawn, but the stirrups and plates are left up for twenty-four hours. From the floor level up to 20 in. of center, the concreting is done with boards in the usual manner—see illustration, page 16414; for filling in these last 20 in., cross lagging is used. The joints between the sections are pointed with a mixture of three parts of Portland cement to one of fine sand.

At the stations at both ends of the line, the two tubes will run into one, which will have a diameter of 23 ft. The engineers have not yet made a decision with regard to the permanent electric system which is to be adopted, as they wish to be free to avail themselves of any new improvements. They estimate that the journey from station to station will take four minutes, which would give an average speed of 22 miles an hour.

The up Waterloo tunnel is now under Stamford Street, between Prince's Street and Duke Street, and is still wholly in the clay. The adjacent tunnel, which, as described above, is being worked under compressed air, has reached Broadwall. Going toward the City, the two tunnels have not quite reached the London, Chatham, and Dover Railway Company's bridge; but now that they are clear of the District Railway Company, and the air lock has been removed, locomotives can be used in both tunnels. As they are of the smaller section, greater speed of construction is possible, and a speed of three rings per shift, or 10 ft. per twenty-four hours, is being maintained.

The deck of the stage is 7 ft. 3 in. above high water mark. The machinery carried on it comprises one 5 ton, two 3 ton, and two 2 ton cranes; four 100 horse power boilers, locomotive type; three dynamos, 100 volts and 112 amperes; one ditto 200 volts and 112 amperes; two 250 horse power air compressors, by Messrs. Markham & Company, of Chesterfield. The compressed air receivers are under the staging.

Messrs. Mowlem & Company's engineer in charge of this contract is Mr. William Rowell. Mr. Rowell, assisted by Mr. C. Campbell, Stud. Inst. C.E., has worked through and checked all the triangulation which had been done by Mr. Dalrymple Hay, as described last week.

DRAWING FOR ENGINEERS.*

By FRANK ABORN, Member of the Civil Engineers' Club of Cleveland.

SINCE accepting the invitation of your committee to read a paper on drawing, the idea has continued to grow upon me that I was "carrying coal to Newcastle." Skill in drawing is a prime factor in the engineer's equipment. It is in hourly requisition in his daily work. How can I tell him anything new concerning it?

These are the conditions that have confronted me in preparing this paper; and, because of them, I have chosen to discuss the beginnings rather than the ends of acquisition, feeling that constant users of drawing will more readily understand and take more interest in discussing a few facts concerning the process of learning than they might in anything I could say about its application.

In discussing this subject the great difficulty is to keep in sight the simple fact that drawing is purely a descriptive agent. This is the one fact that, in this connection, should never be forgotten. Kept in view, profitable discussion is possible, and once finding lodgment in the learner's mind, the acquisition of skill in drawing is only slightly less certain and rapid than learning to walk or to talk.

Drawing is precisely analogous to verbal language, except in the scope of its application, but, within its own peculiar limits, it is much clearer and more concise. Drawings are only essays in lines, which have the advantage over written essays in that they require less time in execution and may be read at a glance even by the uninitiated. Drawing is the natural Volapuk. Everything may be described in words; but certain classes of ideas, mostly those of form, may be more concisely as well as more completely expressed in lines. And to read verbal essays one must be familiar with the language in which they are written, while drawing may be read with the same facility regardless of nationality. These are important advantages, but the most important of all is the ease and rapidity with which drawing may be read. To realize how great this advantage is, it is only necessary to imagine oneself attempting to read the descriptions of two similar mechanical devices, one of which is in drawing and the other is in writing. Both are equally complete and exact, but what a difference in the time, strength and capability required to read and comprehend their respective meanings! The drawing may be read easily by almost any one, while to read the written description requires time, close attention, and, above all, a mental training of an unusually high order.

Looking at drawing from this standpoint, and regarding it as merely a means of expression, puts us on common ground; and now, if you will pardon me, I would like to remind you of something else that you are entirely familiar with, but which it is necessary to mention in order that I may put myself in complete touch with you: I refer to the application of drawing in practice. Let me call to your minds the part drawing plays in the development of any new engineering enterprise. First, there is the general conception of the way a given end is to be attained. Then comes a series of preliminary sketches, the chief function of which is to assist in crystallizing the thought. After this comes more precise drawing. Everything, at this point, is exactly placed. Relations of parts are determined, sizes are established and interferences are avoided. Nothing more can be done preparatory to actual construction except to lift the picture out of the working drawings, so far prepared, and by thus showing how the device will appear when completed, make it clear where changes may be made which will secure greater economy of space or improve the general appearance. The final set of drawings is now made, including as many illustrative, detail sketches as will reduce the chances for misunderstanding and the necessity for verbal explanation to a minimum.

Such procedures involve two kinds of drawing, one of which describes dimensions and the other expresses appearances. Both kinds of drawing are in constant requisition in all varieties of construction work. Final drawings of both kinds must be instrumental, otherwise they cannot be sufficiently exact. But preliminary sketching, the thought-requiring, thought-provoking and thought-developing drawing, is almost exclusively free-hand.

The well-rounded draughtsman, then, must have command of both. He must be able to describe form pictorially as well as in dimension, and have the capacity to express himself promptly, clearly and concisely both instrumentally and free-hand. But such draughtsmen are rare. All can execute dimension drawings, while very few have full, ready command of pictorial expression.

In light of the fact that what are called mechanical draughtsmen are to be met with on every hand, while persons possessed of practical command of free-hand pictorial skill are rarely found, it would seem a hazardous statement to say that pictorial skill is the easier of attainment, or that it is primary to command of dimension drawing, but such are the facts. Free-hand pictorial skill may be acquired in less time than any other form of drawing, and, being acquired, all other varieties of drawing are mastered with the least expenditure of time and effort. Indeed, free-hand skill so prepares the way that, if mastered, orthographic projections, isometric, perspective and all the draughtsman's arts are understood instantly they are presented. The reason for this, as well as the proof that it is so, will readily appear if inquiry is made into the cause of the present condition.

A very brief investigation will show that it is due to an illusion regarding pictorial drawing and the absence of illusion regarding dimension drawing. To comprehend the full force of this fact, to understand what a part it plays in hindering the acquisition of skill, and to appreciate how simple and straightforward both teaching and learning to draw will be, when illusion is dispelled, it will be only necessary to make some inquiry into how we see and determine what constitutes resemblance.

Seeing consists in recognizing the fact that similar optical sensations are derived from similar sources. One object is recognized to be a horse and another to be a man, because the optical sensation derived from each is similar to that we remember to have experienced before, and to have proved to have been derived from a horse or a man, as the case might be. So infallible is this rule, that all things are alike from which similar optical sensations are derived, that the thought of an exception has no natural excuse. But there is a very common exception to the rule, which is met in every picture that is seen. A picture is a picture of an object only when the optical sensation it gives rise to is similar to that to be derived from the object itself and there is nothing to suggest that there is any important difference between them. But there is a very radical difference, and failure to properly appreciate it is the prime cause of all the difficulty every one experiences in learning to draw. It causes effort to draw to be invariably misdirected. It insures that, for a longer or shorter time, at the outset of learning, in each individual case, every thought, every observation and every act shall be from a wrong point of view and on entirely mistaken premises. And this, too, in the most unshakable confidence in the correctness of both, but more or less distrust of personal capability to execute.

Before intelligent effort is possible, all this must be changed. The beginner in drawing must be brought to doubt everything but his own power to learn. He must be brought to question his understanding of conditions and requirements and to doubt the truth of his premises, but not to lose faith in himself or in his powers to gain.

Whether the individual is learning dimension or pictorial drawing, in one particular, at least, does not matter. Progress in the attainment of skill in any direction is entirely dependent upon the dawn of intelligence, and this is impossible in the presence of illusion. With regard to the hand, the pencil, or the paper, or the slate, in the elementary stages, all that is required is that they shall be capable of making and taking marks that can be easily seen. The prime

* Read June 11, 1894.—From the Journal of the Association of Engineering Societies.

factor is intelligence. When any one comprehends that all drawing is descriptive, in the same sense that writing is descriptive, the drawing of lines will be undertaken with a clear understanding of what their true function is. As the understanding becomes more fully developed, discrimination will become more and more acute and the demand will be created for finer and finer execution, which will induce the successful effort to devise ways and means of meeting it.

Ruskin has somewhere said to this effect: "To learn to draw, one must come to look at things with his natural eyes." That is to say, he must look at things not as objects, but as surfaces, as the child looks at the sky at night, seeing all the stars as so many sparks on a plane, rather than as so many distinct bodies and systems at varying distances from us. Every one does this in dimension drawing, but no one does it in pictorial drawing. If they did, present conditions would be the reverse of what they are, and every one would learn pictorial drawing without difficulty, and learning dimension drawing would be child's play to what it is now. For when any one perceives the dissimilarity between picture and object he will intelligently approach all delineative problems because his point of view can never be mistaken nor his aim ever be wrong or uncertain.

Much has been and still is said about "talent" in drawing, meaning thereby that there is a certain quality of mind necessary to its attainment. Whether all people may become true artists need not be discussed here; but that peculiar "talent" is required in the acquisition of practical skill in pictorial drawing, such as would admit of its being used as freely and readily as writing, has not the slightest foundation in fact. That such skill is not common proves nothing. Learning to draw is a question of state of mind and not of quality. Practical command is within the reach of every one. It may be speedily acquired by whoever will assume and maintain the proper point of view. Whether any one attains to art is dependent upon conditions similar to those which maintain in literature. The great question in drawing, as in writing, is place. Is the line in the place to most effectively express the idea? is no less an important question than is the sequence of sentences in writing and speaking. This way of looking at it simplifies every phase of drawing. Nothing could be more straightforward, but, unfortunately, few things are so generally misapprehended. To see how deep rooted this misapprehension is it is only necessary to observe how loose, baseless and sentimental most of the talk is that is used in this connection. Advocates of drawing have a good deal to say about art, for instance, which is as much out of place in this connection as it would be to talk about art in literature in connection with learning to read before the ability to express one's self intelligibly in words has been established. There is a good deal of generalization indulged in to the effect that learning to draw induces the exercise of all the cardinal virtues. Mere sentimental gush, which is belied by the lives of most of those who should be its chief exponents, who, so far as I know, are no more cleanly, orderly or moral than other people. Such ceaseless exaggeration does no good, but actual harm. It tends to bring into disrepute what in truth is a most hard headed, practical tool, not only as a means of expression, but as a means of developing a broader and better command of the intellectual faculties. Such effervescence tends to belittle the subject itself; but there is another class of expressions in common use that are at least unfortunate in that while they are not exactly false they are not wholly true, and, if not actually misleading, they do not contribute to dispelling illusions nor the evidence of misdirected effort. For example, lines are commonly regarded as comparable with letters, and for this reason instruction in drawing uniformly begins with practice in line making in some form, however it may be disguised. This is a mistake. Drawing is a language, it is true, and it is impossible to have any just conception of it except from this standpoint. But the statement so often met with that drawing is a language of which the straight and curved line are the alphabet is utterly incorrect and misleading, notwithstanding it is the view held by Dr. Harris, commissioner of education, and many others.

Drawing is a natural language, like speaking, and has no alphabet. Letters are mere arbitrary symbols, fixed in their form, while lines are variable. Not subject to caprice, however, but changing both in form and character with every modification of the point of view, precisely as the form and construction of sentences change under similar circumstances. Even the shortest line, a point, is a full sentence. It is in every way equivalent to "It is here." It expresses a fact of position as completely and more concisely than could be done in words. A line of more than one point expresses position, direction and distance. It is, at least, the equivalent of "This is the direction and distance between two points." Whether a line is rough or smooth, straight or crooked, is secondary. Whether it is most effectively placed is primary. There are also other forms of expression in common use in this connection, which, though they do not actually befog the mind, do not contribute to clarifying the intellectual atmosphere.

It is common to say that an object is drawn, meaning that it is delineated. But such a statement cannot be true. An object can no more be drawn than it can be written. As an object may be written about, so it may be drawn about. A picture may be drawn, but not an object. A picture can have but two dimensions, while every object must have three. It is also common to say that the object is looked at when it is drawn, but this, too, is incorrect. In drawing, the intelligently directed eye does not direct itself at the object, but beyond or by it, a fact which will be further explained farther on.

As I understand it, the engineer values drawing exactly in proportion as he is able to use it supplementary to verbal language. He desires the ability first to express himself in it as freely as he does in writing. He cares no more what effect the general possession of such skill among the masses might have upon art than he does what effect a new invention is going to have on an older one. What he desires is command of a tool which will enable him to accomplish more with less effort. To this end the established systems of teaching drawing have been proved totally inadequate. Their whole reliance is based upon doing or executing a certain number of prescribed things with a certain degree of precision. They are ponderous, stupid and inefficient.

That the average individual does not gain possession of this tool language by himself is plain. And that the teacher can only help him to do so in proportion as he himself understands the requirements of the case and knows how to meet them goes without saying. It is manifestly not enough that the individual goes through a given series of executions, for if it were, every grammar school pupil would be able to draw anything. The simple use of drawing, as is now so general, with a view to securing greater efficiency by means of correlation, is also unproductive of proper understanding and is unproductive in the very large majority of cases. Drawing from objects most carefully selected and with the assistance of criticisms from those who know may fail for reasons which I shall explain farther on. A knowledge of perspective is everywhere proved to be inadequate. If it were not thus, every student of descriptive geometry would be an all-round draughtsman, and they are not. Modeling in clay will not develop a command of pictorial drawing; if it would, every modeler and carver would be a draughtsman in the best sense, and they are not.

So much is preliminary; but it has been necessary in order that common ground between us may be assured. The real facts which I most desire to make clear are so infinitesimal and yet so perfectly plain to be seen, that they are uniformly overlooked, as I overlooked them for many years, expecting to find something deep, intricate or obscure. But so plain and simple are the steps in learning to draw that the only marvel is that they need even to be suggested. Yet so long a chase have they led me and so difficult do I find it to make myself understood that I have trespassed on both your time and your patience. But the rest is soon told.

Allow me at this point to remind you of a few simple, commonplace facts. The first of these facts is that nothing can be seen except it hide something else from view. For example, I could not be seen by you now were it not for the fact that I prevent your seeing some of the wall behind me. If the button on my coat did not hide some of the coat, it could not itself be seen. If my hand did not hide a part of my body, it would not be visible. And if my thumb did not prevent some of my hand being seen by you, it could not be known that I had a thumb.

If, then, you were to make a picture of me at this time, you would not draw me, but my silhouette. If you were to make a picture of the button on my coat, you would not draw the button, but the shape that the button hides. To one this hidden shape would be almost, if not quite, a straight line, to another it would be an ellipse, while to still another it would be a circle, and no one would look at the button while describing it, but he would look beyond it. Likewise with my hand, in no case would it be drawn, but the shape that it hides; or, speaking more exactly, the base of the pyramid of rays of light reflected from the hand to the eye would be drawn.

It will be seen from this that the ability to draw is not dependent upon the possession of any modicum of knowledge; neither is it dependent upon any peculiar quality of brain, but it does depend upon the absence of all illusion and a clear, unclouded intelligence regarding requirements. In other words, learning to draw is dependent upon a state of mind. To get into this state of mind is the business of the learner, and to induce this state of mind is the duty of the teacher. It is not enough that this or that has been done, it is not enough to draw fine lines, make fine executions nor to draw from the antique.

The acquisition of skill in drawing is precisely similar to all other processes of development. It is not unlike the development of an invention. It consists, first, in a struggle for comprehension. Nothing is polished or finished until it is fitted, nothing is fitted until it is located, and manufacture is not begun until everything else is done. Development and manufacture cannot be successfully carried on simultaneously in anything, particularly anything educational. Every drawing must be made for one of two purposes—it must be a means or a product or end. In proportion as it seeks to be both, it fails in both. If a drawing is a means, it can have no value; if it is an end, it is much for itself, or a part of something else, and has more or less value according to the condition of the market. Learning to draw is an educational or developing process, the drawing of every line is done with a view to an end which lies outside of the doing or the line. In the beginning stages it is a means of correcting the understanding of requirements; after that it becomes a means of improving the power of discrimination. Then it becomes a means of expressing ideas, and, finally, it is the means of emotional expression and culture. It is a perfectly direct highway, unmistakable as a turnpike when once seen, passing without deviation from intelligence to culture through the conscious exercise of power. Whether the aim or destination is power or culture, the ways and means are in nowise affected.

The first step in development is to dispel all illusion regarding the relation between picture and object. This is best done objectively, but it is a delicate operation. If it is done right, the result is favorable, quiet and certain. I will not burden you with the details of a complete course as I would lay it out for children, but will suppose, if I may, that there were some of you who cannot draw pictorially and that I wished to illustrate how you might be taught. I would choose some object that could be so placed that in some one respect there would be a marked case of foreshortening, bringing out the strongest possible contrast between the pictorial and actual relations of parts.

I might select a chair for the purpose and place it where its back would be foreshortened, as shown in Fig. 1. The class being now instructed to draw something that would show how they see the chair from where they sit, the result would no doubt resemble Fig. 2. Each of these results would be an exact exposition of the state of mind regarding the requirements of drawing of the individual who made it. And what the effect of making it may be depends upon how I, as the instructor, proceed. What I do in this capacity depends upon the purpose I have in view. If I desire an immediate result, I criticise the execution and the condition and quality of the pencil and paper, as well as point out errors and suggest errors in the drawing. Learning to draw under such management will be exceedingly slow and very doubtful. If I wish to concentrate my forces and bring out errors with effect, the number of different ways I might proceed depends upon my ingenuity. For instance, by laying a stick across the rail of the back of the chair, as shown in Fig. 3, and by thus calling attention to where it is seen and making it clear that, because the stick is seen and should be drawn higher in the picture than the back of the chair seat, makes it clear that the rail itself, since it touches the stick, should also be drawn higher than the back edge of the chair seat. Or the same end might be secured in a simpler way. It might be done by simply calling attention to the fact that the spindles of the chair back are seen below the rail, while they have been described above it.

It may be brought out, in this connection, that describing the spindles above rather than below the rail

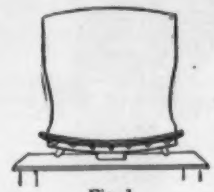


Fig. 1.

is a falsehood. But, however it is done, it is ineffective or rather insufficient. Objects may be described over and over again, and there will remain a large number, if not a majority, who do not learn. If, however, my purpose is to come at the cause of error and make that clear, rather than to point out the error, I shall make use of the background. In every case I shall ask him to show me what the misplaced part hides. This he will do instantly. He will then comprehend where it should have been placed and why he failed to place these. In the present case I should ask the pupil if he could see the whole of the top of the chair seat. If he answered yes, I should, by making chalk marks on the chair seat that I would know to be hidden to him, bring him to see that he could not see the whole of it and what prevented. There is no one so dull of comprehension that he cannot comprehend this, and very presently any one will come to understand the cause

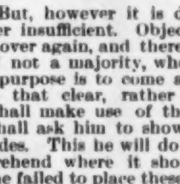


Fig. 2.

of their errors and avoid them. They are, then, intelligent. But intelligence is not enough. Skill is what is wanted. The ability to describe what can be seen is only the entering wedge. Engineers do not draw for fun. It is business with them, and business rarely if ever requires them to describe what is present and visible. Such things are their own best exponent, drawing about them is not called for. What the engineer requires is power, which is the ability to describe absent objects or things that exist only in his imagination.

As soon, then, as intelligence is established, the exercise of the imaginative faculties should be taken up and vigorously pursued; beginning with the description of present objects from imaginary and inaccessible points of view and proceeding to pure invention.

But approximate work will not do. The discriminating sense must now be developed. The subject matter in this case must be such as will demand the

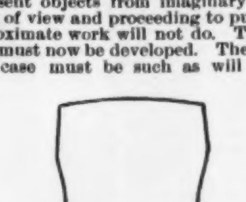


Fig. 3.

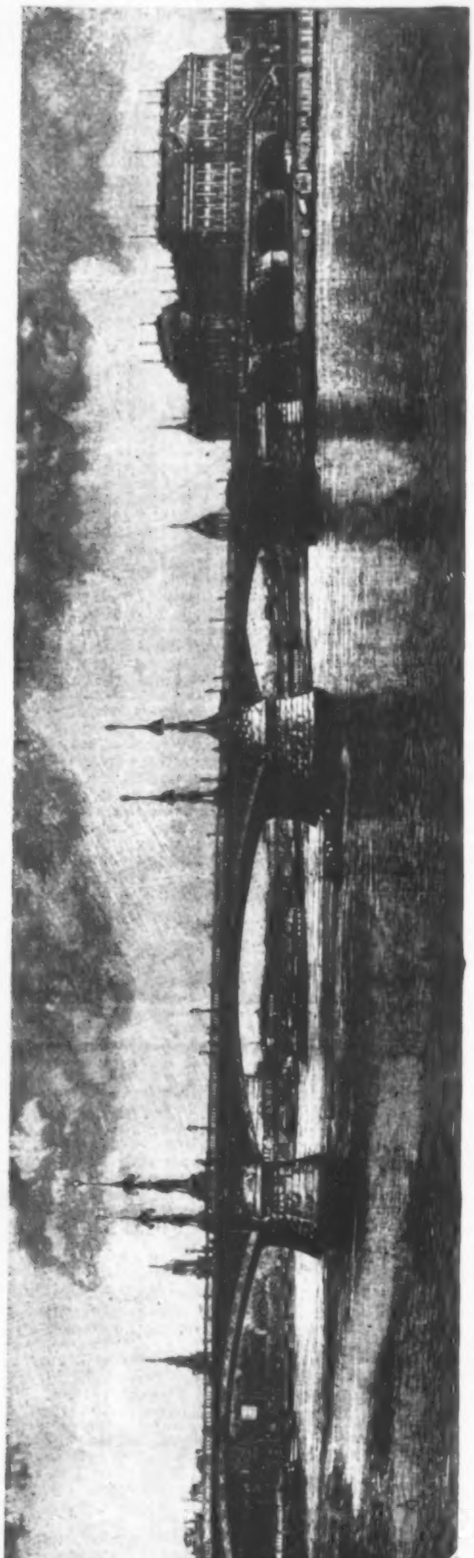
closest observation of relations, at the same time it must have, in itself, such an interest for the student as to enlist and hold his constant and undivided endeavor. Such a subject for study is the human head from life. Nothing else is so fascinating, so exciting, so instructive or more cultivating.

In all work, when rightly aimed, there is a natural constantly increasing demand for better execution. At the proper time, in the place and in the proper degree, technique will have its proper attention. But it cannot economically precede intelligence nor take the place of power.

THE KONIGIN-CAROLA BRIDGE, DRESDEN.

THE completion of the fourth bridge over the Elbe, which has been named the "Konigin-Carola-Brucke" in honor of the Queen of Saxony, denotes real progress in the improvements being made in the city of Dresden, the crowning point of which will be the Ringstrasse. All new structures are being built on a grand scale, so as to maintain the reputation for beauty enjoyed by the city, which is called the Florence of the Elbe, and therefore, it was necessary that the bridge should be a very fine one.

Many insisted that any kind of a bridge at this point



THE NEW KONIGIN-CAROLA-BRUCKE, DRESDEN.

would disturb the historic beauty of the place, and no more forcible argument could have been raised against it, for no city could be prouder of anything than Dresden is of the beautiful view from the Bruhl Terrace of the city, with the background of mountains dotted with villas and castles. But fortunately these fears have been proved groundless, for the bridge is, in itself, a work of great beauty, from both an artistic and a technical point of view, and it harmonizes perfectly with the rest of the picture. Both the view of the bridge and the view from the bridge are all that could possibly be desired; and even a native finds many new beauties in passing over the bridge, while for a stranger the scenery is wonderfully fine, with the Bruhl Terrace and the Belvedere, the Academy of Arts, the dome of the Frauenkirche, the Hofkirche, and the Opera House on one side, and the Loschwitz Mountains on the other.

The bridge itself is chiefly the work of Stadtbaurath Klette, who was presented with the cross of the Albrechts Order at the opening of the bridge, in the presence of the King and Queen of Saxony, and other members of the royal family. He was assisted in his work by Stadtbaumeister Pressprich and Mr. Pasdirek, architect. The bridge was built in the three years extending from August, 1892, to the opening day, July 6, 1895, and it cost more than $714,000. The two piers in the river were carried to a depth of 31 ft. below the water line by means of caissons 114 ft. 9 in. long and 32 ft. 9 in. wide, and weighing 220,400 lb. The entire foundation of the bridge, the pillars and parts of the arches, are made of rammed beton cement, being only covered with sandstone. The arches over the water are of iron; the middle span is 180 ft. 5 in. long, and those on each side 170 ft. 7 in. The iron work required weighed nearly 2,000 tons. The bridge is 1,640 ft. long and 52 ft. 5 in. broad. The Altstadt end of the bridge is at the junction of Amalienstrasse and Marschallstrasse, and the end in the Neustadt at Carolaplatz, near the new buildings of the Department of Finance.

The structures above the piers add greatly to the elegance of the bridge, which is one of the most beautiful structures in Dresden, and will play a most important part in the traffic of the capital of Saxony.—Illustrirte Zeitung.

A NEW TYPE OF STEAM MOTOR.

AT the Sheffield Technical School, on the evening of July 3, Professor Ripper delivered an address on a new type of steam motor, which is the outcome of a very large amount of careful investigation by Mr. W. Schmidt, of Aschersleben. The Master Cutler presided, and there were present Mr. J. G. Lowood, Mr. J. F. Moss, and many representatives of engineering firms. Before the lecture, the company visited the engine room, and inspected the machine in working order, and general satisfaction was expressed.

Professor Ripper said the engine was submitted to him some time ago for his opinion of it, and he at once thought there was merit in it far exceeding the usual type of steam motors. The feature of the motor was the use of superheated steam to a much higher degree of superheating than had ever been adopted previously. The economical results of the invention were remarkable, and had only been produced by an extremely careful working out of a design which should overcome the previous difficulties engineers had met with in dealing with superheated steam. Of course, said the professor, superheating was not unknown in this country. As early as 1859 the famous English engineer, John Penn, not only introduced superheating in marine work, but gave a very interesting account of many other applications of a similar kind by other English engineers. In a few years, however, practical experience showed that there were many difficulties in the way of its use, chiefly arising from the difficulty of the lubrication of the pistons and slide valves. About this time also the minds of engineers were somewhat diverted from superheating by the fact that much higher steam pressures were being adopted, carrying with them also higher temperature. Increased pressures were followed by the compound engine, and the economy which had previously been obtained by superheating was more easily obtained by the use of high pressures and compound engines. Therefore, for many years past, superheating had been in abeyance in this country. This, however, had not been the case in South Germany, where they had from time to time followed up the question, and latterly a very considerable impetus had been given to it by the introduction of more successful systems of superheating. Among the best of those was undoubtedly that of Schmidt, who had devised a superheater of most ingenious construction, the feature of it being that where the intensity of the heating was greatest the superheater itself was protected by the passage through it of wet steam at a high velocity. The steam afterward passed forward to the engine in a reversed direction to that of the chimney gases—a device which enabled them to obtain steam at a maximum temperature, while allowing the gases to pass away up the flue at a minimum temperature. Accompanying the superheater was a specially constructed motor, whose principle was largely based upon that of the gas engine. There were no glands or packing of any kind, except the piston rings, and the friction of the engine was extremely small. Superheated steam at a temperature of 800° Fah. had been successfully used in the engine with very marked results as to economy, and without the smallest damage to the engine. About 700° Fah. was the usual working temperature with this engine. From 300° to 350° Fah. was the temperature in ordinary engines. One secret of its success was the method which the inventor had used of exposing one side of the piston to the air, as in the gas engine, and the fact that the slide valves were kept cool by the exhaust steam, this passing away through the center of those valves, which were of the piston type. The professor said that the experiments recently conducted by him at the school had shown a consumption of 17·18 lb. of steam per indicated horse power per hour. This was a result that had only been possible in the past with engines of the compound condensing kind, and it would be considered very good indeed for such engines. The engine under test, however, was only a simple non-condensing engine. The pressure of steam used was 35 lb., and the number of expansions about five. The engine, compounded condensing, had given a result—obtained by Professor Schroeter, of Munich—of 10·17 lb. of steam. This was 20 per cent. lower than that of the best result ever recorded by any practical engine. Superheating was undoubtedly the next step in steam engine economy, and commenced a chapter in the history of steam engineering which would have similar results in points of economy to those introduced with double and triple expansion engines. The lecturer then explained in what way it was possible with superheating to produce such high economy, and pointed out that it was due solely to the prevention of condensation in the cylinders, stating that it was more effective for that purpose than any other device known. The steam in the engine tested was dry, and even superheated to the end of the expansion, showing that the cylinder was absolutely free from the moisture which existed in the ordinary type of engines, in proportions of from 20 to 60 per cent., or more. The secret of steam engine economy was dry steam in the cylinder, and although many devices have been adopted to accomplish this desideratum, superheating was by far the most effective. The particulars of the tests that had been made at the school were fully set forth and explained by the professor, who said they were only the beginning of a very interesting series which would be carried out during the forthcoming session. The engine and superheater in question were the first of their kind in this country, and he considered it a great privilege to have the opportunity of making investigations upon it. He was indebted to his friend, Mr. W. Radcliffe, who had placed the engine at his disposal, and at the disposal of the students of the school for experimental purposes, and it was owing to his enterprise that the engine had been introduced into England. It seemed likely that there was a considerable future for the invention.

M. NADIEIN'S COMPOUND SIPHON.

THIS siphon, of somewhat original shape, consists of a system of single siphons, or bent pipes of increasing bore, which fall one into the other, all terminating in

the lower part of the thickest one. As soon as the smallest pipe is filled with fluid, and it works, the whole system is brought into action. The explanation of this lies in the fact that while the liquid from the smallest pipe passes down through the lower portion of the second pipe it carries down part of the air contained therein, thus rarefying it and causing the liquid to be sucked through the second pipe. In this way a very small constant supply of fluid is required to keep the appliance periodically and automatically at work.

In the case of a compound siphon beginning with the smallest pipe of ¼ in. diameter, a supply through $\frac{1}{8}$—$\frac{3}{16}$ in. pipe is sufficient therefor, while if the smallest pipe be of $\frac{1}{8}$ in. diameter, a supply of $\frac{1}{16}$—$\frac{3}{32}$ in. will make it work. On the other hand, the force of the flush and the speed of the discharge do not depend on the rate of supply, but on the section of the largest pipe. A siphon terminating in a pipe of 1 in. diameter empties a 2½ gallon basin in eight seconds, while in the case of the largest pipe, being of 1¼ in. diameter, a 3½ gallon basin is discharged in less than five seconds.

The action is automatic, and the intervals between the successive discharges may be minutely regulated, that is to say, it may be brought into action every two minutes, five minutes, ten minutes, every half hour, or every hour, according to the requirements of the case. Such regulation would depend on a combination of pipes of certain sizes, with a suitable rate of supply of the liquid into the basin to be discharged.

While discharging the contents of a vessel much quicker than a single siphon of the same section, and with much greater force, this siphon serves a much more important purpose than merely emptying vessels, since, in discharging liquid, it is capable of sucking in and mixing with itself a considerable amount of air through the overflow pipe (if used), as well as through the short ends of the smaller pipes at the end of each discharge, while the larger pipes are still at work. This action, in the first place, removes the foul air from the basin (as in the case of a urinal), and, second-

ly, in mixing fresh air with impure liquid it assists the chemical action of the oxygen upon the organic matter.

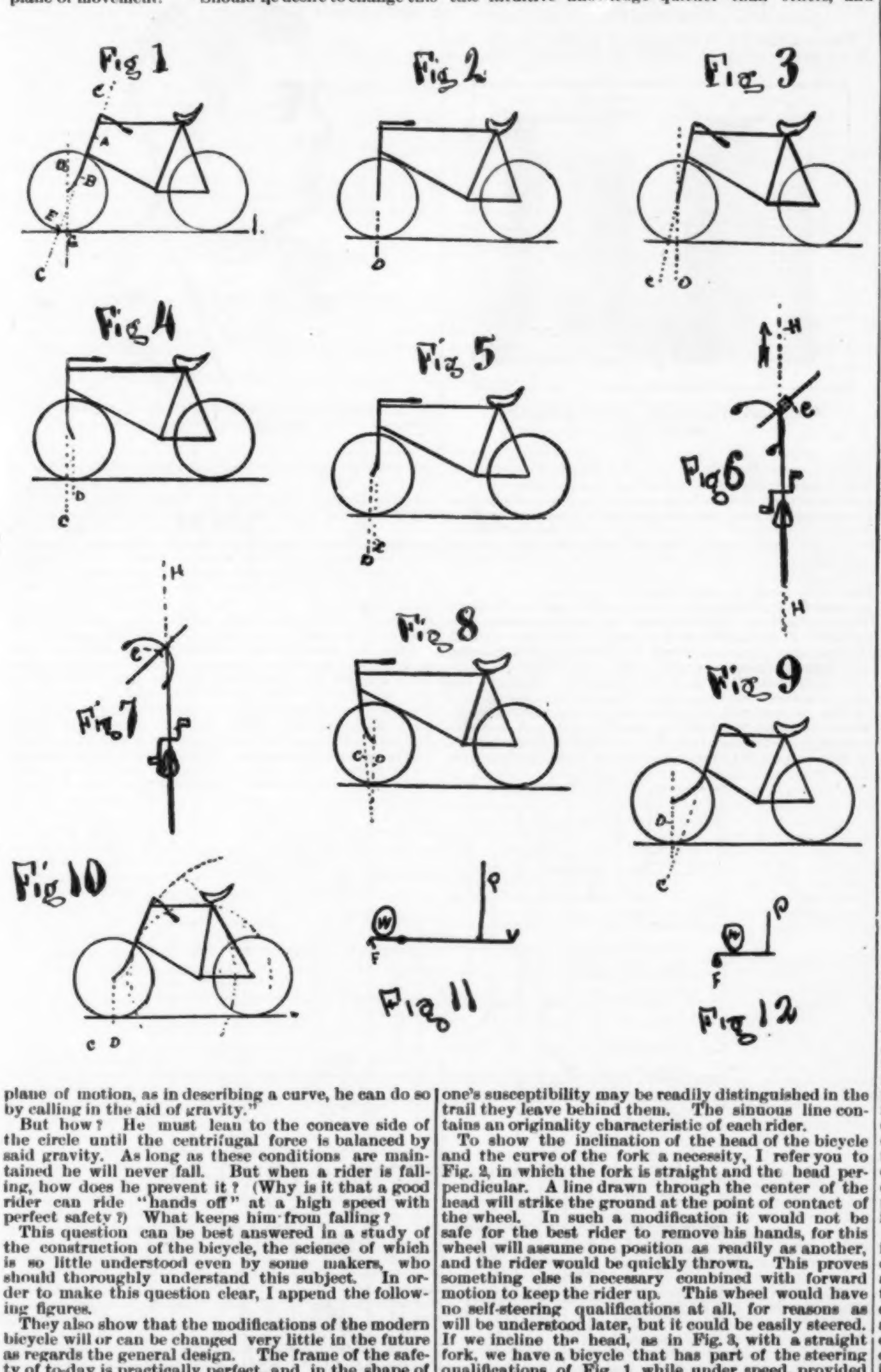
It will be understood from the above that this siphon may be arranged either for automatic emptying or flushing purposes, as the case may be. It is proposed at present to work by its means all sorts of urinals in large dwellings and buildings, such as hospitals, schools, hotels, barracks, railway stations, etc., in order to get rid entirely of the smell of rotting urine, without either excessive waste of water, use of disinfecting chemicals, or attendance.

WHAT KEEPS THE WHEELMAN UP?

To the Editor of the SCIENTIFIC AMERICAN:

In your issue of August 3, 1895, in your article on the physics of the bicycle, you ask this question: "What keeps the wheelman up?" and you have failed (except in a general way) to answer this question to my satisfaction, and, I know, to the thousands of your readers.

"It is a physical fact that a body in motion persists in maintaining its plane of motion." "A body set in motion tends to move in a straight line, and will do so unless affected by a force acting on it in a different direction." "A wheelman is propelled through space at a velocity sufficient to cause him to maintain his plane of movement." "Should he desire to change this



plane of motion, as in describing a curve, he can do so by calling in the aid of gravity."

But how? He must lean to the concave side of the circle until the centrifugal force is balanced by said gravity. As long as these conditions are maintained he will never fall. But when a rider is falling, how does he prevent it? (Why is it that a good rider can ride "hands off" at a high speed with perfect safety?) What keeps him from falling?

This question can be best answered in a study of the construction of the bicycle, the science of which is so little understood even by some makers, who should thoroughly understand this subject. In order to make this question clear, I append the following figures.

They also show that the modifications of the modern bicycle will or can be changed very little in the future as regards the general design. The frame of the safety of to-day is practically perfect, and in the shape of this, combined with the above, lies the answer as to why he keeps up.

In Fig. 1 I show the modern design. In this frame the inclination of the head, A, and the curve forward of the fork, B, are of the utmost importance. If we draw a line through the center of the head, shown by dotted lines, C, it will cross a line, D, drawn perpendicular from the hub of the wheel and will strike the ground in front of line D at E. This distance depends on the sensitiveness of the head, A, or vice versa.

That this line through the center of the head comes to the ground in front of the center of the lead wheel is of the utmost importance, as will be seen further on.

The frame of the safety bicycle is a compound lever combining the second and third orders, Fig. 11. The fork and handle a lever of the second order, Fig. 12. It will be noted that the curve in the fork, B, Fig. 1, throws the wheel forward. If we take hold of the right handle of a bicycle and draw it toward us, the lever of the second order shows itself and the center of the wheel, e, Fig. 6, or its point of contact to the ground moves to the right side of a line, H, Fig. 6, drawn through the center of the frame. If now we are moving forward on a bicycle and are falling to the right, we pull on the right handle proportionately or until we bring into force enough centrifugal action to balance the attracting gravity. Within a limited force, we can right the wheel by leaning our body to the left. This brings into action the compound lever, and as a body tends to move in a straight line by reason of its momentum, the wheel is righted.

When one first mounts a wheel and feel themselves falling to the right, it is but natural that they grab or pull on the left handle. This only causes them to fall quicker by reason of pulling the base line from under them.

The sense of guiding or balancing becomes a second nature, and some people are more sensitive and acquire this intuitive knowledge quicker than others, and one's susceptibility may be readily distinguished in the trail they leave behind them. The sinuous line contains an originality characteristic of each rider.

To show the inclination of the head of the bicycle and the curve of the fork a necessity, I refer you to Fig. 2, in which the fork is straight and the head perpendicular. A line drawn through the center of the head will strike the ground at the point of contact of the wheel. In such a modification it would not be safe for the best rider to remove his hands, for this wheel will assume one position as readily as another, and the rider would be quickly thrown. This proves something else is necessary combined with forward motion to keep the rider up. This wheel would have no self-steering qualifications at all, for reasons as will be understood later, but it could be easily steered. If we incline the head, as in Fig. 3, with a straight fork, we have a bicycle that has part of the steering qualifications of Fig. 1, while under speed, provided the line passing through its head strikes the ground the same distance ahead of the center of the wheel, and the seat and pedals are in a relative position.

To make this steering quality clearer, I refer you to Fig. 4. In this frame it will be noticed that the fork curves back. A line drawn through its head will strike the ground ahead of center of wheel, as in Fig. 3. In moving forward the wheel has a tendency to follow as in a common caster. The resistance of the wheel to turning and obstructions in its path tends to make it self-steering or balancing by pushing it back. But the fact that the fork curves back of the center of the head would make this bicycle very hard to steer, for the reason that the center, e, Fig. 7, is thrown to the left when the right handle is drawn.

Fig. 1 has this same caster action, in spite of the fact that the fork curves forward by reason of the line through the head striking the ground ahead of the center of the wheel.

The fork of frame Fig. 4 can be turned clear around without tending to raise the front of frame. It is the same in Fig. 2. Fig. 5 shows same design as Fig. 4, with the wheel turned half around and the curve of fork forward. In this case, if one removed their hands from the handles, the wheel would have a tendency (under motion) to return to former position, as in Fig. 4. If this construction is still further modified, as in Fig. 8, it brings into action another quality which makes a bicycle self-steering. This is caused by the inclination of the head. This same quality also forms a peculiar advantage in the construction of Fig. 1.

If we turn the wheel half around in either design, the front end of frame will be lifted up. The lowest position will be when the wheel is turned straight forward.

In Fig. 9, but in a more marked degree, the rider's weight will tend to keep the wheels in line. Fig. 8 combines two of the advantages of Fig. 1, but has the fault in steering of Fig. 4, and the design is ungainly.

In Fig. 9 it will be noted that a line through the center of the head will strike the ground back of the center of the wheel. In this case, were it not for the tendency of the front end of the frame to be lifted, the wheel would turn half around. But this tendency to turn is more than compensated for by the rider's weight, and if the distance between the lines is very great, the bicycle will be very hard to steer. This was the case with some of the former makes.

In frame shown in Fig. 1 all of the advantages and none of its disadvantages are obtained. The design is strong and graceful, and in time the design will become fixed. The rider, in order to exert all the force possible, lowers his handles in order to get a good pull, which permits him to exert more than his mere weight. This bending over presents less surface to the action of the air. It also makes it easier for the rider to pedal slightly backward. This brings the seat farther forward. The forward shifting of the saddle is limited, for the reason that most of the rider's weight must be on the rear wheel.

I show this tendency in Fig. 10, which seems to give the promise of the standard design for the future.

From the above it will also be seen that further improvement, at least as regards the design of the safety bicycle, is extremely limited.

The tendency of inventors and manufacturers will be to improving details in other parts that contain objectionable features. FINIS M. BARNEY.

Elm Creek, Neb.

[FROM THE ALUMNI JOURNAL.]

CONDENSED MILK.

By BYRON F. MCINTYRE, Ph.G.

THE residents of our large cities are familiar with the unsweetened varieties of condensed milk, and to a larger extent the people of the whole country are acquainted with the sweetened or canned condensed milk, and yet how little is known of the detail and method of preparation of these important food products!

The farmer contributing his share of the raw milk to a condensing factory can testify to the restrictions, inspections and obligations exacted by the factory management to secure pure milk, but the consumer rarely discovers the untiring vigilance and scientific methods put forth to insure a palatable and pure condensed milk.

The art of condensing milk has been perfected largely through improvements in mechanical details, but the so-called "vacuum principle" of removing water from milk remains unchanged, and is the universal process of condensing not only milk but many liquids injured by high temperatures. A brief consideration of this "vacuum principle" and the mechanical appliances necessary for its operation may refresh our knowledge, and be helpful by way of contrast with the essential features of the preserving or cold process of condensing.

A vacuum is defined as an inclosed space void of air or matter, and by vacuum principle we express briefly such a combination of pumps, condensers and tight inclosures, or pans, as will permit of drawing from the whole apparatus the larger proportion of air contained therein, so that a boiling process can be carried on in the pans at a very low temperature or under vacuum conditions. The importance of this reduction of quantity of air in the pan is seen when we consider that normally, or with the atmospheric pressure at fifteen pounds to the square inch, a boiling temperature would register 212° F. With but seven and one-half pounds of atmospheric pressure, or one-half of the air pumped out of the apparatus, the boiling temperature would register 170° F., and with nearly all of the air pumped out, the boiling would continue actively at 100° F. In other words, a vacuum process is perfect just in proportion to the low temperature obtained and held during the working of same.

It is apparent that there must be destructive changes in the milk when heated to 212° F., otherwise the necessity for vacuum conditions would not exist, so that an inquiry as to the chemical changes must apply to temperatures below 212° F. Authorities can be quoted confirming the statement that serious chemical changes are wrought in milk by vacuum process temperatures, decreasing the nutritive value of the milk, and producing a series of decompositions, occasionally noticed in burned flavors, that renders the product unlike plain milk in its constituent parts.

The consumer and non-expert observer will notice that the physical characteristics of vacuum process condensed milk are: Loss of fresh milk odor, almost complete destruction of fresh milk taste, and when mixed with water to dilute to original milk there is no separation of cream or milk fat, as in plain or fresh milk. The toleration of the human stomach of material digestible and questionable is well known, particularly in food stuffs, both cooked and uncooked, and while we have in normal milk a universal food

suited to all ages of the human family, whether in health or sickness, there is a growing volume of evidence from scientific physicians and chemists, unfavorable to the reputation of milk in any form that has been artificially heated, whether for sterilization or condensation.

It is a fact that there can be no successful condensation of milk, either by the boiling or freezing process, without a rigid inspection of milk from properly fed cows. Fresh or new milk, because of excess of inorganic constituents and deficiency of albuminoids, should be evenly distributed throughout the year, by proper management of the sexual relations of the herds, and every precaution must be exercised in the aerating, cooling, care of milk in transit from dairy to factory, and in the cleanliness of utensils. Negligence of these details opens the door to disastrous germ contamination.

The cold process of condensation involves principles the opposite of boiling, the central idea being to duplicate artificially the phenomena as observed in nature, and by securing an upper surface refrigeration, or freezing effect, all solids are rejected and pure ice only is formed. The familiar fact of boyhood days, of lifting a transparent pure sheet of ice from the surface of a mud puddle, may be duplicated from the milk in the freezing process. The successful production of thin layers of ice is a special feature of the process and can only be accomplished by having the freezing trays of metal, and suspended in a zero chamber, free from insulation or direct contact with the walls of the chamber. Under these conditions there is perfect rejection of solids until such time as the layers of ice become sufficiently thick to act as an insulating covering, when the ice and solids freeze at metal contact. This layer of ice, however, is crushed at periodic intervals, and thereby the freezing effect is confined to the upper surface, and no ice is formed at metal contact. The production of solid ice for the removal of water from solutions has been an industrial process of limited application, applied to the concentration of acids and alcoholic liquors, and in every instance known to the writer, the ice freezes solid from either a metal, stoneware or wooden base, and this ice appropriates very largely inseparably dissolved salts, mechanically suspended particles, gases and odors.

In the surface process of freezing, there must be space contact on one side and liquid contact on the other side of the film of ice to have a perfect rejection of solids. The ice formed by this process on black coffee or strong hydrosulphuric water, if rinsed, is odorless, tasteless and pure, when frozen in thin layers.

In the boiling of water, we find that, irrespective of the force of the heat and rapidity of the boiling, if the steam is unconfined, the temperature of 212° F. is not exceeded, and in the freezing chamber or closet, irrespective of temperature, which may be 10° below zero, the milk will remain at 32° F. as long as there is unfrozen milk.

From recent reliable data, working with the highest type of refrigerating apparatus, as compared with a single effect vacuum apparatus, there is practically the same efficiency in converting the water of milk into steam and ice respectively. The direct product in each example is condensed milk, and the indirect or by-product is steam in the boiling process, which is in practice a waste, and in the freezing process it is ice, with a marketable value as a refrigerant.

The several features of the process covered by letters patent and patent applications of the inventor need not be detailed in full, but briefly it may be stated that when the milk is first received in the factory, it is examined and a sample put aside at the receiving platform, and at once passed over Baudelot coolers, where the temperature of the milk is reduced to within two degrees of the cooling medium, after which it is standardized to a definite percentage of milk fat. All possible germs are thus at once arrested in their development, a marked contrast to the vacuum process, where the milk is held warmed and ready for the vacuum pan for one or two hours, but unfortunately under very favorable conditions for germ growth. The cold milk from the cooler flows into shallow metal pans properly mounted on trucks and track, connecting with the freezing closets, in which are arranged direct ammonia gas expansion pipes. The pans have an upper surface area of about fifty square feet, and 100 or 200 gallons have been found a proper charge for each pan. The rapidity of the freezing effect can be doubled by spreading the milk over 100 square feet of surface. The temperature of the freezing closet is kept at or near zero, and the milk is permitted to freeze until a film of ice is formed, when an automatic stirring apparatus breaks the ice into particles or crystals. This operation of film freezing and breaking up continues until all the milk is converted into a mushy mass of ice crystals, with thick milk held between the crystals of ice. This mixture of crystals and thick milk is poured into a rapid running centrifugal machine, with an instant separation of the condensed milk from the crystals, the latter forming a heavy bulk of hard snow. When assayed this snow shows about two-tenths of 1 per cent. of milk solids.

The first freeze usually separates one-half of the water in the milk, and two additional freezes are required to reduce it to proper consistence.

Estimating that milk contains 86 per cent. of water, 78 per cent. of this water can be frozen to ice and readily separated with a centrifugal speed of 1,500 revolutions per minute in a 30-inch basket.

The limit of condensation is not a question of converting water into ice, but rather a problem of detaching the heavy, tenacious, condensed milk from the ice crystals, which is accomplished by increasing the speed of the centrifugal proportionate to the density of the milk.

In practice the condensation is usually four to one on a milk fat basis, which forms milk of sufficient density to meet the public demand. When the condensed milk is diluted with water, it dissolves completely, forming milk with normal flavor and taste, and from which cream will separate as from ordinary milk. When subjected to the Babcock method of fat testing, the fat separates clear as with ordinary milk, quite unlike this test when applied to the condensed milk by the boiling process, which gives a mixture of clear and broken-down products, that prevent a satisfactory reading of the milk fat.

In keeping qualities the cold process condensed milk will rank with the so-called pasteurized standard. The destruction of germ life at 32° F. seems quite as extensive as the heating or pasteurizing by heat at 174° F.

The prolonged keeping qualities of ice cream at low temperature, often for weeks without impairment of taste or flavor, naturally confirms the statement that no detrimental changes are wrought in the milk by the freezing temperatures, and careful chemical examination fails to discover decomposition effects in the constituent parts of the milk.

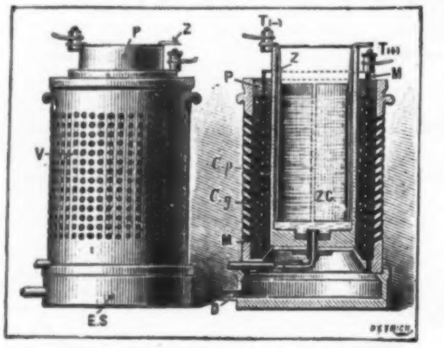
Butter and cheese can be made from the diluted condensed milk, and the action of the organized ferments is the same as in normal milk.

The cold process has been applied to other products requiring condensation with signal success, in albuminoid solutions, and particularly when the integrity of flavors is desired, and where ferments are wasted and made inert by heat, or their power diminished by the production of secondary products of little value.

An incidental advantage of the process is that unskilled labor can be used, and that in whatever way the process may be employed in its industrial applications, the by-product ice has some compensating value to offset the fuel account.

NEW PROCESS OF DEPOLARIZING BATTERIES.

THE polarization of batteries is, as well known, due as a general thing to a deposit of hydrogen upon the



WALKER-WILKINS DEPOLARIZING BATTERY.

positive pole that increases the internal resistance. The depolarizers are all oxidizing compounds. Unfortunately, their action becomes less and less efficacious in measure as they are reduced, that is to say, as they absorb hydrogen. A continuous depolarization by means of oxygen, ozone and air has been tried, but all such means have failed. We must point out a new arrangement that will certainly interest electricians, and that permits of depolarization by means of air. The accompanying figure shows a non-polarizable Walker-Wilkins battery. It consists of an amalgamated zinc cylinder, Z, immersed in a solution of caustic potash contained in a porous vessel, P. This latter is inclosed in a large perforated vessel. The space between these two vessels is filled in with granulated carbon (Cg) and powdered carbon (Cp). Into the center of this carbon is inserted a perforated nickel cylinder, M, which is connected with the positive pole and communicates with the terminal, T (+). The terminal situated at T (—) upon the zinc is connected with the negative electrode. The annular part filled with carbon is closed by a circle of wood. The air passes through the tube, D, traverses the carbon and flows through the apertures in the external vessel. It is very evident that this arrangement might be applied to cases in which it would be desired to make use of oxygen, ozone or any other oxidizing gas, and which would be introduced through the tube D.—La Nature.

PICTURES BY TELEGRAPH.

MR. W. H. LOWD, train dispatcher for the Northern Pacific Railroad, at Duluth, Minn., has suggested an interesting method of sending pictures by telegraph, which is illustrated herewith.

The drawing or sketch which it is desired to transmit by telegraph is traced in an enlarged or reduced form, by means of a pantograph, on one of Mr. Lowd's cipher charts. A section of the chart is shown in Fig. 1. This chart consists of a sheet of paper, on which are ruled 476 blocks about a quarter of an inch square, which are each subdivided into nine lesser blocks and squares, numbered from one to nine. Across the top and bottom of the chart are letters designating each of the larger blocks, and on either

FIG. 2.—DRAWING FROM CHART SHOWN IN FIG. 1.

side are like designations of the blocks running across the sheet, similar to the methods employed in atlases for the location of points on maps. The letters are supplemented by short words, which can be used instead. The words are preferable in long distance messages, for the simple reason that in frequent transfers they are not so apt to be wrongly sent. In indicating lines passing between the square the fraction is given by using the figures which the line divides, as thus, for instance: $\frac{2}{3}$, $\frac{3}{4}$, $\frac{1}{4}$, etc. In sending curves each square is given through which the curve passes. Blocks to be shaded are named, as are also colors.

After the tracing is on the chart it will be found that each line or curve can be very closely located by the little squares and described by the cipher giving the two dimensions. The points described by the cipher are then sent by telegraph to the receiving end of the line. The operator there has a similar chart before him, and follows with his pencil the points given in the telegraphic message. When the tracing is com-

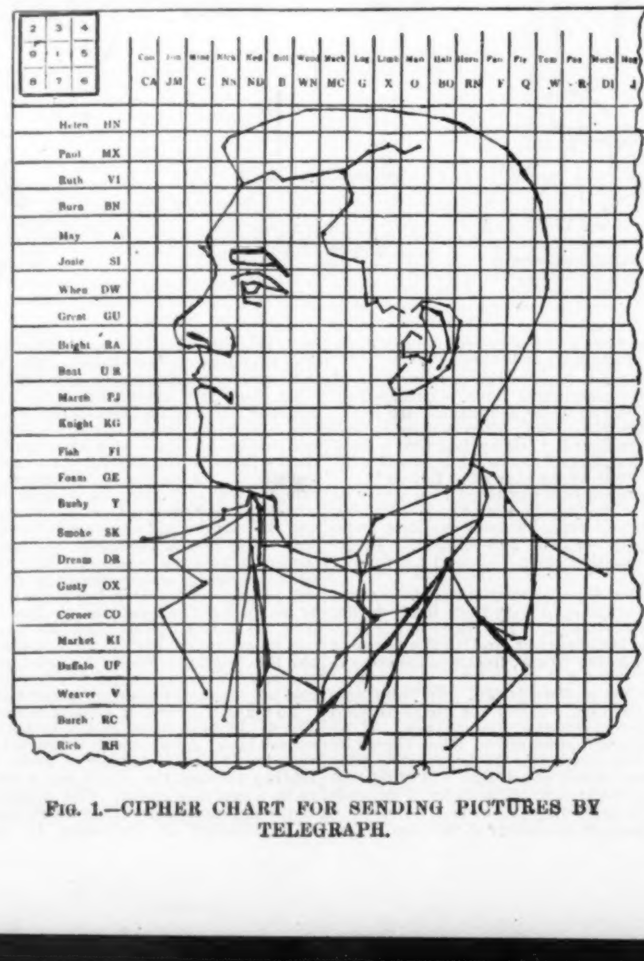


FIG. 1.—CIPHER CHART FOR SENDING PICTURES BY TELEGRAPH.

pleted, it is handed over to an artist, who fills in the sketch as required.

Fig. 2 is a portrait of Mr. Lowd, drawn from the chart shown in Fig. 1. The cipher message from which the tracing on the receiving chart was made is as follows:

The word "From" denotes a new starting point. Keep the pencil on the paper until the word "From" appears again. When figures follow each other (as 1, 5, 1/8, etc.), they are the ones in the block last indicated by words. The word "To" is understood.

From Ruth Ned 8 "To" May mine 6 Josie Nick 8 when Nick 2 great mine 3 great Jim 3/8 bright Jim 3/8 bright mine 8 7 boat mine 1/4 7/8 March mine 3/4 1/2 knight mine 3/8 fish mine 7 foam mine 3/8 foam Nick 7/8 bushy Ned 3 1/8 bushy Nick 7 smoke Nick 3 smoke can 7.

From bushy Ned 3 7 dream Jim 1 gusty mine 5 corner Jim 9 weaver mine 6.

From bushy Ned 7 dream Ned 7 burch Nick 1.

From dream Ned 3 burch Ned 4.

From bushy Ned 3 6 dream Ned 6 5/8 Buffalo Bill 9 weaver Ned 4.

From Buffalo Bill 9 weaver Mack 9 burch Mack 2.

From dream Ned 6 corner log 3 corner limb 8 Buffalo Mack 4 weaver Mack 9.

From dream Ned 4 dream Bill 4 dream Mack 1/4 gusty log 3/4 corner log 3.

From foam horn 4 7/8 bushy hall 4 smoke limb 2 dream log 1 dream Mack 1/4.

From smoke fan 2 gusty log 3/4 dream log 1.

From foam fan 3/8 bushy fan 3/8 smoke fan 2 dream hall 3/8 rich wood 2.

From rich hall 5 buffalo fly 3/8 corner fan 8 dream hall 3/8 market man 8 rich log 5.

From foam horn 4 foam fan 1 bushy fly 9 smoke Tom 8 gusty much 2.

From smoke Tom 8 gusty Tom 9 market fly 5 1/4 corner fan 8.

From Ruth Ned 8 Paul Nick 1 3/4 Helen wood 3/4 Helen limb 3/4 Helen hall 1 Helen horn 7 Paul fan 5 Ruth fly 1 burn Tom 9 Josie Tom 1/2 when Tom 1/4 bright fly 5 knight fan 9 foam horn 4.

From March mine 3/4 March Nick 3/8 6 5.

From bright mine 7 6 boat Nick 3/4 bright Nick 6 5 3/4.

From bright mine 3/8 1/2.

From when Nick 3/8 when Ned 5/8 4 when Bill 6 when Ned 5 9 7/8 5/8 5.

From when Ned 9 great Ned 5/8 1/2.

From Josie Bill 7/8 Josie Nick 3/8 1/4 Josie Ned 3/8 when Bill 4.

From Ruth Ned 8 Ruth Bill 1/2 1/4 Ruth Mack 3/8 Paul log 3/8 Paul limb 1 Paul man 3/8 1/4.

From Ruth Mack 3/8 burn log 2 9 May Mack 5/8 Josie Mack 1/2 5 Josie log 1/4 great log 3/8 great limb 2 1 3/8 great man 9.

From great man 1 4 great hall 2 1/4 great horn 7/8 bright horn 8 boat hall 5 March man 1 March limb 5 3/4 boat man 9.

From bright man 5 1/8 boat man 2 3/4 boat hall 3/8 bright hall 7/8 great man 3/8 1/4 great hall 1 5/8 bright hall 6 boat hall 1.

From bushy Ned 3 bushy Bill 1/2 smoke Bill 1 dream Bill 4.

From corner limb 3/8 corner man 1/4.

From Josie mine 5 3 4.

Hair cut close on back of head and neck. Hair parted and combed forward and up.—Electrical Review.

PSYCHIC EFFECTS OF THE WEATHER.*

By EDWARD A. BEALS.

THE impressed forces, apart from hunger, which have done more than anything else to change the state of mankind, are those pertaining to the weather. No matter how much we may grumble and find fault with its ever-varying changes, we ought always to remember that this property of variability is a powerful agent, undoubtedly introduced for the express purpose of causing men to move about. It is not hard for me to conceive how the influence of cold might have impelled primitive man to rush out of his cave, and, with club in hand, slay some weaker or less cunning animal, that he might thereby use its skin as a protection from climatic rigor. Our natures, both morally and physically, have been vastly influenced through the introduction of clothing, and if we accept this hypothesis, it was originally due more to weather extremes than to modesty. It is doubtful if mental evolution without changeable weather conditions could have made any progress worth speaking of, and instead of the civilization that now surrounds us we would yet be in that state described by Mr. Darwin as a "tailed quadruped, probably arboreal in its habits."

Before the advent of Christianity many offerings and sacrifices were made to appease deities believed to control the winds, the thunder and other atmospheric phenomena, and it may be that one cause of the universality of polytheism was owing to the inability of the existing mind to conceive how such diversified weather could be made by a single deity. A cloud obscuring the sun at the time of the summer solstice was esteemed a very bad omen by the semi-civilized Incas, and a whole nation could thus be thrown into despondency and gloom by the occurrence of this, to us, easily explained natural phenomenon.

Plutarch says that when Hannibal first came into Italy with his victorious army, the alarm and consternation of the Romans were greatly augmented by the prodigies then happening, which, besides the more common signs of thunder and lightning, consisted of a rainfall of red hot stones, and the letting down of several scrolls from the heavens, upon one of which was plainly written, "Mars himself stirs his arms." The rainfall of red hot stones was probably of volcanic origin, and the scrolls an aurora, with the writing an illusion, due to a fevered imagination. It can thus easily be seen how the terror inspired by unusual meteorological conditions must in olden times have often determined the course of great historical events.

For the purpose of pacifying the anger of deities held responsible for phenomenal weather, ceremonies, and even sacrifices, are still made by the uncivilized tribes of to-day. One of the popes thought bad weather the sole product of the "evil one," and had a manual prepared to be used by the clergy on suitable occasions, for the purpose of expelling those demons held responsible for its disagreeable features, and the Catholic "Key to Heaven" and the Episcopal Prayer Book yet contain prayers for fair weather and for rain.

Salutations in nearly all ages and countries are more or less marked by climatic environment as well as religious sentiment, while they also tend to show how much all the world is interested in the weather. Among Orientals the Persian greeting of "May your shadow never be less;" the Arabian of "May God strengthen your morning;" and the Egyptian of "How goes the perspiration?" all typify a feverish, burning climate, with violent light and strong shadows, whereas in the occident the abrupt "Good morning," "Wie gieht es," or "Bonjour," indicate a muggy, windy, or chilly climate, and are characteristic of industry, hurry and restlessness. The ceremonies of salutation in the East are extremely passive, and frequently occupy five, ten, or even more minutes before they have been punctiliously complied with.

Ancient weather prophets largely based their prognostications upon the restlessness of animals, and numerous are the proverbs handed down to us in commemoration of this fact. As an illustration, an unknown writer says:

"But with the changeful temper of the skies,
As rains condense and sunshine rarefies,
So turn the species in their altered minds
Composed by calms and discomposed by winds."

And a concordant distich by Shakespeare is:

"If the sun sets weeping in the lowly west
Witnessing storms to come, woe and unrest."

Major Dunwoody's collection of weather proverbs includes a long list of animals thus affected: and the psychical information bearing on this subject, which is embraced within the covers of this little book, is unsurpassed by any other publication.

Seneca said: "The empire of the world has always remained in the hands of those natures who enjoy a mild climate." This may have been true in his time, but it is now no longer so, for that climate which maintains the highest civilization and stimulates the mind to its greatest activity is one where there is a moderately severe winter, calling forth careful forethought during the preceding summer in order that the discomforts attached to the rigorous season may as far as possible be artificially lessened. It is true, however, that the inhabitants of all the world are indelibly impressed with the effects of permanent climate.

"The cold in clime are cold in blood,
Afric is all the sun's, and as her earth
Her human clay is kindled."

Then again Seneca affirms that "Those who dwell near the frozen north have uncivilized tempers." It is quite probable the uncivilized tempers Seneca attributes to the frozen north were due more to the existing state of civilization during his time than to the permanent effects of climate, as it is now conceded that those of the north are phlegmatic in disposition, and not so excitable as are their more sensitive and irritable contemporaries of the south.

As the weather affects the minds of those subjected to its permanent influences, so likewise are all natures more or less swayed by its seasonal and even by its diurnal variations. Those having delicate and refined temperaments, like poets and prose poetic writers, are more susceptible to these changes than ordinary people, although all readily respond when in poor health.

Those with lingering diseases die more often at the change of weather; and the mortality reports of Dr. Farr, of England, and Dr. Stark, of Edinburgh, show the mild and temperate months to be the healthiest, while those either of extreme heat or extreme cold or of excessive moisture invariably swell the death rate.

It is said that a sudden rise of temperature predisposes those liable to an attack of mania, and that one sign of growing neurotic diathesis is an inability to keep at the top of one's condition and in good tone in unusual weather. In Texas, Dr. Cline states that the number of deaths caused by diseases of the nervous system is fifty per cent. greater on days with abnormally high temperature than on days with normal temperature, and that equable conditions in pressure and temperature are favorable for the treatment of these diseases.

A German doctor who accompanied Napoleon's army during its retreat from Moscow has furnished us with an interesting account regarding the action of intense cold on the minds of the soldiers who participated in this memorable event. His observations show quite conclusively that very low temperatures cause a diminution in will power and often a temporary weakening of the memory, which, in some instances, he affirms, resulted in a permanent derangement of the mental faculties. Dr. Rose, in a paper published in a New York medical journal, quotes him as saying that: "With the first appearance of moderately low temperature, about 5° above zero, many of the soldiers were found to have forgotten the names of the most ordinary things about them, as well as those of the articles of food, for the want of which they were perishing. Many forgot their own names and those of their comrades, which was noted in the strong as well as in the weak. Others showed more pronounced symptoms of mental disturbance, and not a few became incurably insane." These men were dispirited, poorly clad, and many were weakened by disease and hunger, therefore the cold was not alone responsible for these effects, as zero weather is rather stimulating than otherwise in its action upon the well fed and healthy. Its inducing agency, however, cannot be altogether neglected, and there is probably no person ever having been exposed to very cold weather who has not noted some degree of mental lethargy when in an uncomfortably chilled condition.

Religious fervor is considerably diminished by low temperatures, if we accept the conclusions arrived at by a Baptist preacher, who flourished hereabout for a number of years during the early Minnesota days. It is related that at a prayer meeting, one bitter cold night, he requested the rather small congregation to draw up near the stove, as his observations had led him to believe that cold weather was not conducive to piety.

As opposed to cold air, which, when not too severe, is bracing and highly stimulating, we find that hot air is always depressing and relaxing. It causes languor and lassitude, and when abnormally warm, entails oppressed breathing.

The operation of hot and cold on the human sensibilities was remarked upon by Sydney Smith, whose rather sophistical deductions were that: "Very high and very low temperatures establish all human sympathy and relations. It is impossible to feel affection above 70° or below 20° F. Human nature is too solid or too liquid beyond these limits. Man lives to shiver and perspire." Ben Jonson, on the other hand, ridiculed such ideas and claimed that the mind was imponderable, immortal, and beyond the reach of earthly influences.

No matter which view we accept, there are but few, if any, of us, even when in good health, who have not experienced times when everything appears dark and gloomy, when little ills are magnified into terrible evils, and we have what is called a fit of the "blues." These depressed mental states are most frequent on dull, disagreeable days, when the air is muggy and the pressure least, or when thunderstorms are imminent and the electrical potential or the wind has changed. It is also on such days that domestic animals become so restless; when hens sit on the fence and oil their feathers, or the cat is morose and peevish. Teachers and jailers often note that a spirit of restlessness asserts itself among their charges during such weather, and on these days commercial travelers aver that "there is no use in trying to do business today." Suicides are then most frequent and every one is inclined to be cross and irritable.

Attention has been called to the controlling effect of this weather on work by Dr. Crothers, of Hartford, Conn., who says: "In my own case I have been amazed at the faulty deductions and misconceptions which were made in damp, foggy weather or on days in which the air was charged with electricity, and thunderstorms were impending. What seemed clear to me at these times appeared later to be filled with error. An actuary in a large insurance company is obliged to stop work at such times, finding that he makes so many mistakes which he is only conscious of later that his work is useless. In a large factory, from ten to twenty per cent. less work is brought out on damp days and days of threatening storm. The superintendent in receiving orders to be delivered at a certain time takes this factor into calculation."

The clergy who study their congregations are aware that they are as impressible by weather conditions as is mercury. A very hot day, in which there is no wind and where there is not a breath of morning air, is one in which no eloquence will interest an ordinary audience. While a morning in which the sun shines brightly, and there is a gentle, warm, not hot, wind, will call out all the powers of the soul and every faculty of the mind is alert and open to the slightest impression. Such a day fills our avenues with gay people, and the hearts of the covetous shopkeepers are made glad by increased sales and overflowing coffers, while even the busy clerks are unusually pleasant and agreeable. The opposite conditions of wet, windy, or sloppy weather seem also to correspondingly influence the spirits of some people, for on these days they are likewise possessed with a strong inclination to go out into the streets or fields, and some of them have told me that they have to exert considerable will power to prevent themselves from doing so.

From Foster's Encyclopedia of Natural Phenomena is culled the information that dreams of a hurrying and frightful nature and imperfect sleep are frequent indications that the weather is changed or about to change, and that these nocturnal symptoms are experienced by many persons on a change of wind, particularly when it becomes east. When from this quarter it makes most people uncomfortable and produces headaches in persons who are subject to them.

In some portions of South America the north wind, when coming from the equatorial regions, seems to affect the dispositions of the inhabitants; and one writer affirms that at La Plata it amounts to little less than a temporary derangement of the moral faculties, as then cases of quarreling and bloodshed are much more frequent than at any other time.

There is a very interesting article upon the subject under discussion in the January, 1894, number of the American Journal of Psychology, by Professor J. S. Lemon, upon which I have drawn freely for material here used. He concludes by stating that "All our senses put us in rapport with the external world. The knee jerk seems proved to have a weather factor. It is not strange if the eye, e. g., which wants the normal stimulus, in long dark weather causes other changes. Changing moisture in the air changes odors, and many appetites are affected, as touch is still more obviously. Tea tasters work best on fair days."

There have been a number of instances where our leading writers have found it impossible to make any headway unless the weather conditions were favorable. Its depressing as well as exhilarating effects can be traced to a most surprising extent in the works of poets and prose poetic writers.

Dante says:

"Now is the hour that wakens fond desire in men at sea,"

and Gray,

"The curfew tolls the knell of parting day,"

and then puts down, in exquisite forms, thoughts suitable to the hour and place in which he stood.

If we look at Burns, we see the same principle at work. The Lazy Mist says:

"The forests are leafless, the meadows are brown,
And all the gay foppery of summer has flown."

Then following he says:

"Apart let me wander, apart let me muse;
How quick time is flying, how keen fate pursues."

In Burns' "Farewell to his Country," we see the same thing exactly:

"Across her placid, azure sky
She sees the scowling tempest fly,
Chill runs my blood to hear it rave,"

and so on.

John Ruskin is correspondingly affected in that beautiful pen picture of an English misty dawn where

* Read at Minneapolis, Minn., before the Minneapolis and St. Paul Academies of Science, March 6, 1895.—Amer. Met. Jour.

he says: "Morning breaks, as I write, along those Conneston Fells; the level mists, motionless and gray, veil the lower woodlands and the sleeping village, and the long lawns by the lake shore. Oh, that some one had told me in my youth how little a love of colors and clouds would serve me when I should look for those whom I shall never see more."

To follow the effect of weather upon literature would be nearly an endless task, but to do so would remove any doubts one might still have regarding its quickening or slackening of the highest affections of the soul.

It has always been a great mystery to me when, in view of the knowledge we now have regarding the effects of weather upon all life, whether animal or vegetable, and as I have now shown, influencing the highest mental faculties, that so important a factor does not receive greater attention from our physicists and social reformers, and especially at our universities.

MILITARY HOSPITAL, SANTIAGO DE CUBA.

THE principal scene of the war now in progress in Cuba is at the eastern extremity of the island, which is mountainous and covered with thick forests and rank vegetation. The Spanish troops suffer greatly from fevers and wounds, and their chief reliance for medical treatment is the military hospital at Santiago, views of which we herewith present, for which we are in-

DR. RAMON MOROS Y PALACIN.

debted to La Ilustracion, of Madrid. The hospital, which is the finest and best appointed in Cuba, is situated on high ground, where cool breezes are enjoyed. The establishment at the present time is overcrowded with patients. Dr. Ramon Moros y Palacin is the chief medical director.

CLINIQUE OVER WOUNDED SOLDIERS.

CLINIQUE OF OFFICIALS.

EXTERIOR VIEW OF THE EDIFICE.

INTERIOR CORRIDOR.

THE MILITARY HOSPITAL, SANTIAGO DE CUBA.—FROM A PHOTOGRAPH.

[COUNTRY GENTLEMAN.]

A COUNTRY SEAT ON THE ISLE OF WIGHT—APPLEY TOWERS, NEAR RYDE.

APPLEY TOWERS, the seat of Mr. Geo. W. Hutt, is a place of great interest to horticulturists. Not only is it a place of much natural beauty, but it has been well laid out. Besides this, several years ago, I am informed, it was determined to plant out largely of such trees and shrubs as were deemed tender, in order to see if many of them would not prove hardy in the island. As a consequence there are to be met with many things which one never expects to see out of doors even here, in this favored spot. To understand it properly I should say that, as a rule, there are but a few degrees of frost here in winter; though last winter the thermometer indicated 15° below freezing, and more than that in some places.

The occasion of my visit was a rose show, held on the grounds, in a large tent, a usual way of holding one here. I took the opportunity of walking through the grounds to take notes of the trees and shrubs; and after this, Mr. Hutt, hearing of my desire to see more of his place, kindly took me over the grounds again. Some things I saw are quite common in home planting but I note them as showing what they make use of here. In a large bed of evergreens near where the rose tent was there were beautiful specimens of Cleyera japonica, Thujopsis dolobrata variegata, this 12 feet high and in fine shape; Podocarpus japonica, Retin-

ospora plumosa aurea and R. pisifera, both in fine shape, and an Abies polita. The latter sort seems to be a favorite one in England. Near by was an Aralia sieboldi, 8 ft. high, and bushy, and not a leaf had been hurt in the winter.

A surprise greeted me here in a specimen 12 ft. high of Zenobia pulverulenta, and almost in flower. Here, too, was our old greenhouse friend Pittosporum tobira, expanding its white flowers. If I am not mistaken, I read once that Prof. Massey had found this shrub quite hardy in Baltimore. Close to this was a vigorous specimen of the Eleagnus pungens variegata. It was 12 ft. high and as many in width. In many parts of England Magnolia grandiflora was badly hurt last winter, but in this place this did not occur, and some of the trees of it were quite full of flower buds. Olearia haastii had reached a height of 12 ft. This evergreen has a leaf not unlike the common myrtle, and comes from New Zealand. Then there came Berberis hookeri, 8 ft., and Benthamia fragifera, 16 ft. The latter shrub is from Nepaul, and proves quite hardy, as do many other shrubs from there. Trained to a wall, I was delighted to see an old greenhouse friend in the Rhynchospermum asminoides, and not far away was a variegated form of it, a beautiful plant. The Akebia quinata was near it, a vine that does not seem nearly as much valued with the people here as it is with us. New to me was a plant 6 ft. high of Colletia cruciata. It belongs to the family in which buckthorns are found, and comes from Rio.

I have seen several fine specimens of Choisya ternata in England, but one here which was 8 ft. high by 15 ft. wide, was the finest I ever saw, and it was about to flower beautifully. And a Saphora japonica pendula, 10 ft. high and nicely developed, was also finely grown. Chamærops fortuni is rather common in the Isle of Wight. In this place there are good ones 12 ft. high, and as there are both male and female plants, an abundance of perfect seeds are produced. I have said before that this may prove hardy with us. A pomegranate 6 ft. high did not interest me as much as other sights did, as it struggles through in Germantown, and is a nice ornamental shrub at Washington. One of the best Sequoia gigantea I ever saw was here. It is 50 ft. high, and perfect from bottom to top—very different from what many are that I have seen here. An Araucaria imbricata 40 ft. high was also in good condition. This tree, I learn, has produced perfect seeds in England, from which small seedlings have been raised. The Camellia japonica exists in a 12 ft. specimen. There is here the finest Thujopsis borealis I ever saw. It is 30 ft. high by as many wide—a most beautiful specimen.

I could hardly believe my senses when I came to a large tree 30 ft. high and as many in width, with a trunk 18 in. in diameter, and a label on it told me it was the camphor tree, Laurus camphora. A little distance off it looked much as the Gordonia pubescens, both in the way it grew and in the appearance of its leaves. The Lawson's cypress is common everywhere in England, but I have not seen a better than the one here, which measured 40 ft. in height, and had a spread of 15 ft. at base. A plant of the European olive, Olea europæa, was 6 ft. high; Pinus insignis, 60 ft., and a lovely one of Picea cilicica, 40 ft. Cedrus atlantica showed itself in one 40 ft. high by 20 ft. wide at base. Though from Mount Atlas, it is barely hardy at Philadelphia, but a variety called glauca, which has been well recommended by Mr. Falconer in Gardening, is known here, as it is by him, to be hardier than the typical form, and it is besides of a most lovely silvery-green color. Japanese maples are not as common in England as they are with us but there is a well-formed one on this place of the variety Dissectum atropurpureum, which was 5 ft. high. The strawberry tree, Arbutus unedo, was partly hurt in the last winter, though looked on before as a perfectly hardy tree. This tree when young and flourishing bears strawberry-like fruit, which is very good to eat.

Veronicas of a shrubby nature are somewhat common here. I have seen such partly tender ones as andersoni and its variegated leaved variety thriving out of doors, and there is blooming now in many collections V. buxifolia, a native of New Zealand. In Mr. Hutt's collection, I met with another new to me, V. traversii, also from New Zealand. This was a bush six feet high, and its white flowers were just about expanding.

I have said in my former letters that there are but few shrubby magnolias to be met with in England, but on this place there was a fine M. lennei, which, late as it was, was still showing some flowers. Rosa rugosa was represented in both the red and the white kind. As with us, the berries are most attractive in the autumn. Yucca gloriosa is a common garden shrub or small tree in England. The one here was nine feet high. That so much used at home, filamentosa, I have met with but a few times. I had heard that the Douglas fir was producing seeds freely in many parts of Europe, and here I found a 30 foot high tree of it as full of cones as it could be. Quite a new shrub to me in such a situation was Azara microphylla. It has pinnate, shining foliage, and reminded me somewhat of the zizyphus in general appearance. I think it is a native of Chile. It was 15 ft. high. A Picea concolor, 50 ft. high, was most beautiful, and near it, presenting a fine appearance, was a nice tree of a variegated leaved Spanish chestnut, Castanea vesca. In other places besides this, I have seen Spiræa ariæfolia, and it is always beautiful. Its drooping panicles of white flowers are conspicuous in shrubberies in the latter part of July. Another Chilean shrub, looking not unlike a dogwood, was the Aristotelia macqui in its variegated form. The preceding hard winter had not hurt it. It seemed to me to be a quite handsome evergreen shrub. Abelia rupestris, which lives out in Philadelphia, was represented in one six feet high and eight feet wide, and was just coming into bloom. A pretty æsculus, which I took to be Californica, was showing flowers, and later on toward the close of July, I found it fully expanded. The flowers were pinkish white, and it would be most valuable, if it would succeed with us at home, because of its late flowering habit.

One of the finest English oaks I have ever seen is on this place. It is some 7 ft. in diameter at 2 ft. from the ground, and its branches cover an area of 100 ft. in diameter. Some of its main branches are over 2 ft. in diameter. In height it may be about 60 ft. Having had a good chance to develop, it has done so to the best advantage, and it would be most difficult to find a more symmetrical, healthy tree.

Besides what have been already mentioned, I noted the following, many of them well known at home: Virgilia lutea, Mespilus japonica, Weigela floribunda, mock orange, deutzia, leycesteria, cephalotaxus, Rhus cotinus, catalpa, Ribes sanguinea, butternut, Judas tree, osmanthus, and the usual assortment of laurels, sweet bays, euonymus, etc., to be found on all English grounds. In the conservatory, trained to a wall, was beautifully in flower Diplacus glutinosus, a California shrub. Its orange colored flowers are produced nearly all the time, and they are very pretty. And I think a finer display than was made by a Tacsonia van volxemii, which ran over the rafters of the roof, I had never seen. Long clusters of its scarlet flowers made a brilliant display, and this is kept up a long time.

JOSEPH MEEHAN.

LAXTON'S MONARCH STRAWBERRY.

WE have much pleasure in presenting to our readers an illustration of this splendid new strawberry. On several occasions its merits have been fully stated in our columns by those who have seen it growing and cropping. Its size, weight of crop, firmness of texture and fine flavor have been touched upon so frequently during the strawberry season just passed that it is quite unnecessary to detail its many good qualities now. The first-class certificate given for Monarch at the R. H. S. meeting of June 11 was confirmed by the Fruit Committee of that body on June 25, when the

LAXTON'S MONARCH STRAWBERRY.

Messrs. Laxton Brothers, of Bedford, staged fruiting plants, in pots, of their newest introduction.—The Gardeners' Magazine.

ON THE CAUSE OF EARTHQUAKES.

By Prof. J. LOGAN LOBLEY, F.G.S., etc.

IN a recent number of Knowledge I adduced evidence in support of the conclusion that the general climatal conditions of the globe in the Cambrian period were similar to those that now prevail on the surface of the earth.* But although this evidence is so abundant and cogent that the conclusion is inevitable and indisputable, yet its consequences are very generally overlooked, and it is frequently altogether ignored in the discussion of questions on which it has a direct bearing. Notably has this been the case in the discussion on the cause of earthquakes.

A connection between the cause of earthquakes and that of volcanoes is very generally assumed, and Mallet's dictum, that an earthquake is but an uncompleted volcano, is often quoted with tacit, if not expressed, acquiescence. This would seem to imply that both the cause of volcanic action and the cause of seismic action had been satisfactorily determined, and yet this is far from being the result of the long controversy on these two important questions.

Text books usually give several theories to account for volcanic action, and while one hypothesis is on the whole favored by one author, another receives the guarded assent of a second. The cause, or causes, of seismic phenomena are stated still more doubtfully, notwithstanding the mass of facts obtained by the laborious and prolonged investigations of Mallet, and the very valuable and more recent work of Professor Milne in the seismic land of Japan.

There seems, however, to be a very prevalent opinion that a shrinkage of the so-called "earth's crust," consequent upon the secular cooling of the globe, is the primary cause of both earthquake and volcanic phenomena. Mallet not only attributed local earth movements generally to the consequences of a gradual cooling of the globe, but derives volcanic heat also from the tangential pressure of the rocks of the crust by contraction following planetary cooling. What is precisely meant by the "earth's crust," and what the amount and rate of the cooling assumed, are not stated, and so the whole matter is left in a very vague and unsatisfactory position.

To the same shrinkage from planetary cooling is also ascribed the folding and contortion of rocks of all kinds and all ages, except those associated with intrusive igneous rocks, as well as the elevation of mountain chains and the vertical uprise and subsidence of areas both large and small. So repeatedly and so confidently is contraction from cooling stated as being the cause of such earth movements, that it is generally accepted without question. Indeed, a shrinkage of the bulk of the earth is commonly regarded as required to account for the foldings and contortions of the surface rocks, and thus prove the point.

More than fifty years ago, Sir Henry de la Beche wrote: "If we adopt the theory of a cooling globe, and the necessity of the solidified crust of one period, with its covering of sedimentary deposits, conforming to the reduced size of the earth at another, this solid crust, with its detrital covering, would be broken up, or wrinkled, or both, to conform to the new adjustment of parts." So confident did this truly great geologist appear to be that the theory of a cooling globe, with consequent shrinkage, was sound, that he did not think it necessary to state or suggest any other.

And although a thin hard crust with a great central fused mass has since been shown, by Lord Kelvin and other physicists and astronomers, to be incompatible with the proved rigidity of the globe, a settling down and accommodation of the crust to a shrunken central mass is still most confidently assumed. In a recent important work the emission of lava is ascribed to its exudation from a central fused mass consequent upon the pressure of an exterior hard crust.* and in a still more recent text book, earthquakes are attributed to, with other causes, "the snap of rocks that can no longer resist the strain, to which by the cooling and consequent contraction of the inner hot nucleus, they have been subjected within the earth's crust."†

If, however, the general temperature at the surface of the globe was in Cambrian times similar to that of the present day, there can have been no appreciable amount of planetary cooling during the intervening period, and consequently no appreciable amount of contraction of the bulk of the globe, notwithstanding the enormous duration of the time that has elapsed since the Cambrian epoch. If, furthermore, there has been no appreciable contraction during this vast period of time, there cannot have been any contraction in a small unit of time, say a century, to cause dislocation of surface rocks. But there is not merely an earthquake once a century, but without any exaggeration it may be said that in one part of the world or another, there is at least one every week.

The report of the British Association on earthquakes (1851 to 1858) contains a catalogue of recorded earthquakes from B. C. 1606 to A. D. 1842, which, with the catalogue of Professor Perry, of Dijon, from 1842 to the year 1850, gave between 6,000 and 7,000 earthquakes as having been recorded in 3456 years. But the following digest will clearly show that only in very recent times do the records of earthquakes at all approximately correspond with the number of occurrences:

	Annual Ratio.
From B. C. 2000 to B. C. 1000	0·004
" B. C. 1001 " Christian era	0·054
" A. D. 1 " A. D. 1000	0·222
" A. D. 1001 " A. D. 1850	7·740
" A. D. 1551 " A. D. 1850	17·370
" A. D. 1701 " A. D. 1850	35·310

When it is borne in mind that a great portion of the surface of the earth, to take only the land surface, which is merely one-fourth of the whole, is sparsely peopled and without observers to record natural phenomena, it will be readily admitted that it is quite safe to conclude that the annual number of earthquakes between 1701 and 1850 as stated above is much below the fact. An earthquake a week may, therefore, be confidently assumed. Indeed, exactly double this number (104) were actually recorded by Professor Fuchs as having occurred in 1876. In addition, however, to those violent disturbances that are designated earthquakes, there are the earth tremors and earth movements that can only be noted by the delicate seismograph. Disturbance of the exterior rocks of the globe, at one part or another of the earth's surface, must, therefore, be very frequently, it may be safe to say daily, taking place.

The conclusion, consequently, appears irresistible that the cause of earthquakes cannot, with a due regard to absolutely incontrovertible geological facts, be attributed to a contraction or shrinkage of the bulk of the globe, and that, therefore, another cause must be found.

Any cause, to be adequate for the production of constantly recurring phenomena, must be constantly operating and the result of forces continuously acting. So far as our present knowledge extends, there are but two classes of forces capable of disturbing the surface rocks of the globe. These are (1) physical and (2) chemical. By expansion and contraction consequent upon alteration of temperature, lateral pressure and lateral tension of incalculable intensity and power may be produced. By chemical action the requisite alteration of temperature to cause alteration of density, and consequently alteration of bulk, may be produced, to say nothing of the evolution of gases by decompositions and reactions. Again, chemical action may be checked and prevented or suppressed by excessive pressure, and stimulated or permitted by diminution of pressure; and as lateral pressure lessens vertical pressure, increase of heat from slight chemical action, occasioning expansion and therefore lateral pressure, may be the cause of relief of vertical pressure, with the result of allowing more intense chemical action productive of greater heat and still greater expansion, with proportionally increased lateral pressure.

From these considerations it is obvious that physical and chemical forces act and react on each other, and in combination are capable of producing surface phenomena of great magnitude and importance, as well as of a minor character. Here, then, are forces constantly acting or potentially existing that are quite adequate to the production of seismic phenomena, without postulating the shrinkage of a thin crust over a fused interior mass that is alike opposed to the observations of astronomers, the calculations of physicists, and the facts of geology. It is true that the hypothesis of a solid nucleus with an intermediate ocean of fused matter between it and the solid exterior surface crust, as the source of lava, has recently received the support of eminent physicists; but this requires a mere thread of lava, dependent for its fluidity on a temperature rapidly lost, finding its way as a fluid through a thickness of thirty miles of solid and therefore comparatively cool rocks, which certainly appears to be quite impossible.

In the early part of the century Sir Humphry Davy, after his discovery of the elements potassium and sodium and their violent combination with the oxygen of water, advanced a chemical theory to explain vol-

* "On the Climate of the Cambrian Period," Knowledge for November, 1894, p. 260.

* "Geology," by Professor Prestwich, p. 226.

† Geikie's "Class Book of Geology" (1893), p. 110.

canic action, and, later, Dr. Daubeny also favored a chemical hypothesis. These views have, however, been generally discarded as inadequate, but chemical forces and physical forces acting in conjunction appear to be amply sufficient to cause not only seismic, but volcanic action also.

In the year 1888, I brought before the British Association an hypothesis that seemed to me to account satisfactorily for volcanic action, and to meet the requirements of its observed phenomena.* By the hypothesis then explained and formulated, subterranean igneous conditions were attributed to chemical action when allowed by favoring physical conditions, prominent among which was diminution of pressure. To the same physio-chemical agency I attribute earthquakes, and earthquake shocks and tremors.

Earthquakes and earthquake shocks are not infrequent in the neighborhood of active volcanoes, and minor tremors are common on volcanoes during and preceding eruptions. All such seismic phenomena are doubtless due to volcanic action, and, therefore, are primarily caused by what has produced that action. But the earthquakes of non-volcanic regions, which have their centers far away from any active vent, require a further explanation. They are caused, it appears to me, by the same chemical action that originates volcanic phenomena, but acting with less intensity, it does not bring about rock fusion, on which volcanic action depends. It is sufficient, however, to produce heat, gases and vapors with accompanying local expansions and succeeding contractions, and thus it occasions deep seated and sudden fractures that give rise, from separate and distinct dynamic foci, to earth vibrations, which at the surface cause earthquakes and earthquake shocks and tremors.

According to these views, seismic action and those of volcanic and plutonic origin have this in common, that they each originate from chemical action arising and developing from favoring physical conditions. When that action is sufficiently intense to create a rock-fusing heat, then either volcanic or plutonic results will follow; and when the heat produced at any one focus of chemical change, though considerable, is insufficient to fuse the adjacent rocks, an earthquake may be caused.

The sources of seismic, volcanic and plutonic action will, therefore, be in a thin outer rind of the globe resting on an interior solid foundation, and unconnected with any fused central mass, and, consequently, with the exception of regions of fused rock near the exterior, the earth as a whole may be solid to the center, and this would be quite in accordance with the rigidity our planet has been proved to possess.—Knowledge.

* "On the Causes of Volcanic Action," Report of the British Association for 1888 (Bath meeting), p. 670; "Proceedings of the Geologists' Association," vol. xi, p. 1; "Mount Vesuvius," p. 212.

THE BEGINNINGS OF ASTRONOMY.

In the clear Egyptian sky the stars are wonderfully bright, and the inhabitants of the Nile Valley must have observed them in very early days. It was, says Maspero, from very early times a vocation of the priestly colleges to found and maintain schools of astronomy. In the clear nights and the transparent atmosphere of Egypt, the eye penetrates the depths of space far more readily than in any climate much less dry. The first observatories established on the banks of the Nile seem to have belonged to the temples of the sun. The high priests of Ra, the sun god, styled themselves "The great of sight," that is, the chief of those who see the sun, those alone who beheld him face to face, and that from the earliest times employed themselves in preparing maps of the heavens. The priests of other deities followed their example, and in the earliest dawn of history there was not a single temple from one end of the Nile Valley to the other that did not possess its official astronomers, called "watchers of the night." Evening by evening on the high terraces above the shrine, or the narrow platforms over the temple entrances, they unremittingly watched the movements of the constellations across the celestial vault above them, and carefully noted the slightest phenomena of the sky. Some parts of the chart of the heavens known to observers at Thebes between 1800 B. C. and 1200 B. C. have been found carved on the ceilings of temples, and especially on royal tombs, and have thus survived to the present time.

It was a question in ancient times, says Maspero, whether the Babylonians or the Egyptians had been the first to carry their investigations into the infinite depths of celestial space. When it came to be a question as to which of the two peoples had made the greater progress in this branch of knowledge, all hesitation vanished, and the pre-eminence was accorded by the ancients to the priests of Babylon rather than to those of Heliopolis and Memphis.

The Babylonians, says Maspero further, had conducted astronomical observations from remote antiquity. Callisthenes collected and sent to his uncle, Aristotle, a number of these observations, of which the oldest had been made 1,903 years before his time—that is, about the middle of the twenty-third century before our era. He could have transcribed many of a still earlier date if the archives of Babylon had been fully accessible to him.

The Babylonian priests had been accustomed from an early date to record on their clay tablets the aspect of the heavens and the changes which took place in them night after night, the appearance of the constellations, their comparative brilliancy, the precise moments of their rising and setting and culmination, together with the more or less rapid movements of the planets, and their motions toward or from one another. To their unaided eyes, sharpened by practice and favored by the transparency of the air, many stars were visible, as to the Egyptians, which we can perceive only by the aid of the telescope. These thousands of brilliant bodies, scattered apparently at random over the face of the sky, moved, however, with perfect regularity, and the period between their departure and their return to the same point in the heavens was determined at an early date. Their position could be predicted at any hour, their course in the firmament being traced so accurately that its various stages were marked out and indicated beforehand.

The moon, they discovered, had to complete two hundred and twenty-three revolutions of twenty-nine days and a half each, before it returned to the point from which it had set out. The period of its career being accomplished, it began a second of equal length, then a third, and so on, in an infinite series, during which it traversed the same celestial houses, and repeated in them the same acts of its life. All the eclipses which it had undergone in one period would again afflict it in another, and would be manifest in the same places of the earth in the same order of time.

Further observations encouraged the astronomers to endeavor to do for the sun what they had so successfully accomplished in regard to the moon. No long experience was needed to discover the fact that the majority of solar eclipses were followed some fourteen days and a half after by an eclipse of the moon, but they were unable to take sufficient advantage of this experience to predict with certainty the instant of a future eclipse of the sun, although they had been so struck with the connection of the two phenomena as to believe that they were in a position to announce it approximately. They were frequently deceived in their predictions, and more than one eclipse which they had promised did not take place at the time expected. But their successful prognostications were sufficiently frequent to console them for their failures, and to maintain the respect of the people and the rulers for their knowledge.

But all the discoveries which constitute in our eyes the scientific patrimony of the Babylonians were regarded by themselves as the least important results of their investigations. Did they not know, thanks to these investigations, that the stars shone for other purposes than to lighten up the nights—to rule, in fact, the destinies of men and kings, and, in ruling that of kings, to determine the fortunes of empires? Their earliest astronomers, by their assiduous contemplation of the nightly heavens, had come to the conclusion that the vicissitudes of the heavenly bodies were in fixed relations with mundane phenomena and events. If Mercury, for instance, displayed an unusual brilliancy at his rising, and his disk appeared as a two-edged sword, riches and abundance, due to the position of the luminous halo which surrounded him, would be scattered over Babylonia, while discords would cease therein, and justice would triumph over iniquity.

The first observer who was struck by this coincidence noted it down. His successors confirmed his observations, and at length deduced, in the process of years, from their accumulated knowledge, a general law. Henceforward, each time that Mercury assumed this same aspect it was of favorable augury, and kings and their subjects became the recipients of his bounty. As long as he maintained this appearance no foreign ruler could install himself in Babylonia, tyranny would be divided against itself, equity would prevail, and a strong monarch bear sway: while the landholders and the king would be confirmed in their privileges, and obedience, together with tranquillity, would rule everywhere in the land.

The number of observations, like that relating to Mercury, increased to such a degree that it was necessary to classify them. Tables of them were drawn up, in which the reader could see, at one and the same moment, the aspect of the heavens on such and such a night and hour, and the corresponding events either then happening, or about to happen, in Babylonia, Syria, or some foreign land. If, for instance, the moon displayed the same appearance on the 1st and 27th of the month, Elam was threatened; but if the sun, at his setting, appears double his usual size, with three groups of bluish rays, the King of Babylonia is ruined.

To the indications of the heavenly bodies the Babylonians added the portents which could be deduced from atmospheric phenomena. If it thundered on the 27th of Tammuz, the wheat harvest would be excellent and the produce of the ears magnificent; but if this should occur six days later, that is on the 2d of Abu, floods and rains were to be apprehended in a short time, together with the death of the king and the division of his empire.

It was not for nothing that the sun and moon surrounded themselves in the evening with blood-red vapors or veiled themselves in dark clouds; that they grew suddenly pale or red after having been intensely bright; that unexpected fires blazed out on the confines of the air, and that on certain nights the stars seemed to have become detached from the firmament and to be falling upon the earth. These prodigies were so many warnings granted by the gods to the people and their kings before great crises in human affairs. The astronomer investigated and interpreted them, and his predictions had a greater influence than we are prepared to believe upon the fortunes of individuals, and even of states. The rulers consulted the astronomers, and imposed upon them the duty of selecting the most favorable moment for the execution of the projects they had in view.

From an early date each temple contained a library of astrological writings, where the people might find, drawn up as in a code, the signs which bore upon their destinies. None of these works has come down to us in its entirety, but we are in possession of the table of contents of one of them, which contained not less than twenty-five tablets, and which was placed in the library of Assurbanipal at Nineveh. We may estimate, from the summary which it has preserved for us, the amount of work and the number of observations which the Babylonian, and afterward the Assyrian, astronomers must have accomplished during the centuries to make up the materials of their science.

One of these libraries, consisting of not less than seventy clay tablets, is considered to have been drawn up in the reign of Sargon of Agade (B. C. 3800), but to have been so modified, and enriched with new examples, from time to time, that the original is well-nigh lost. This was the classical work on the subject in the seventh century before our era, and the astronomers royal, to whom applications were accustomed to be made to explain a natural phenomenon or a prodigy, drew their answers from it ready made.

Astronomy, as thus understood, was not merely the queen of the sciences, it was the mistress of the world. Taught secretly in the temples, its adepts—at least those who had passed through the regular curriculum of study which it required—became almost a distinct class in society. The occupation was a lucrative one, and its accomplished professors had numerous rivals whose antecedents were unknown, but who excited the envy of the experts in their trading upon the credulity of the people. These quacks went about the country drawing up horoscopes, and arranging schemes of birthday prognostications, of which the majority were without any authentic warranty. The law sometimes took note of the fact that they were competing with the official experts, and interfered with their business; but if they happened to be exiled from one city, they found some neighboring one ready to receive them.

The story thus given in the words of M. Maspero, with very slight departure from exact quotation, is but one out of a thousand passages of rare interest in the splendid volume devoted by the great Egyptologist to the dawn of culture in both Egypt and Babylonia.—Self-Culture.

SPECTROSCOPIC ASTRONOMY.

Dr. William Huggins, F.R.S., delivered recently the first of the series of Tyndall lectures at the Royal Institution on "The Instruments and Methods of Spectroscopic Astronomy," in which a glance was taken at the comparatively modern origin of the new science of astrophysics in 1857 by Kirchhoff and Bunsen, by their determination of the true nature of the dark lines of the solar spectrum, and due to the absorption of the same vapors and gases by which similar bright lines are emitted. The earlier worker, by a sort of curious fatality, missed the true interpretation of the phenomena of the spectrum, and of the marvelous potentiality of the spectroscope as a method of research on the heavenly bodies. Even Newton failed to see the dark lines, although, contrary to the statements of the text books, he did use a narrow slit $\frac{1}{20}$ in. and less in width.

Fraunhofer first observed the spectra of the stars, using a prism in front of a small telescope, but it was not until, in direct result of Kirchhoff's work on the sun in 1859, similar researches were extended to the stars in this country by Huggins, and in the United States by Rutherfurd, and in Italy by Secchi and Respghie, that the new astronomy was born—mater pulchra filia pulchrior.

The early form of spectroscope of Fraunhofer, in which the stars themselves act as slits, has some great advantages, though at the same time great drawbacks. It gathers up all the light of the star into its spectrum, while with a slit spectroscope the whole light can seldom be taken in. When photography is used, whole fields of stars can be photographed with a single exposure. Such fields of stars were projected on the screen by Dr. Huggins. This form of spectroscope was revived by Pickering, and with it in some four or five years he had accumulated spectra by thousands, which, after discussion and measurement, were published in his great catalogue of ten thousand star spectra in 1890.

This instrument fails when the object in the heavens is not a point like a star. It also fails if direct comparison is needed for chemical determinations or for motions in the line of sight. This wonderful method of determining motions of the heavenly bodies, when all other methods completely fail us, was first suggested by Doppler in 1841, and was first developed and applied to the heavenly bodies by Huggins in 1868.

The spectrum of iron photographed together with the spectrum of Sirius was shown on the screen. The minute displacements of iron lines from star lines, when measured by the most refined processes, corrected for earth's motion, gave the motion of Sirius in the line of sight.

A spectrum of Jupiter was shown, recently taken by Keeler, in which the lines were seen to go obliquely in consequence of motion in opposite directions, at limits due to rotation, and doubled in amount in consequence of the position of the sun in the same line as the earth, at opposition, the shift between the sun and Jupiter being added to the shift between Jupiter and the earth.

There was shown the new triumph of the motion in line of sight method in a photographed spectrum of Saturn by Keeler, proving by direct observation the truth of the theoretical view that the rings are not continuous bodies, liquid or solid, but an assemblage of small satellites, each moving in its own orbit.

Finally, it was shown that in a particular case, when a spectrum was common to two stars moving in an orbit, then it was possible, without a slit, to detect and to measure motion in the line of sight, of which an illustration was shown in the remarkable double star discovered at Harvard, β Aurigæ, in this case the shift taking place between lines of the spectrum itself, and not meeting an external scale.

THE CAT AND THE COPPERHEAD.

Mrs. Austin Gibson, of Hill Crest, N. J., set a cage containing a canary on the front porch to give the bird fresh air. The cage had been on the porch about half an hour when a big copperhead snake crawled out from under the steps and stretched itself out in the sun. The canary was making a good deal of fuss about taking a bath, and its fluttering finally attracted the attention of the snake, which immediately started up the steps. As soon as the copperhead reached the porch it coiled itself near the cage, and soon the canary seemed fascinated and unable to break away from the snake's glittering eyes. In its helplessness it uttered pitiful little cries.

This business had been going on several minutes and the copperhead had crawled nearer the cage until it was almost in striking distance of the bird. Its ugly, square head was raised several inches from the floor and its tongue played in and out between its jaws. Then Jason, the family cat, came sauntering around the corner of the house in search of a cool spot to lie down in. He stopped at the foot of the steps and gave the side of his face a wipe with one big paw. He was at the point of resuming his walk when the weak little chirps of the canary attracted his attention. Jason and the bird were firm friends. They had grown up together, and it was no unusual thing for the canary to ride around the sitting room on the cat's back or eat off the same dish with him. The instant Jason heard the bird's plaintive cry he surmised something was wrong and sprang up the steps in the direction of the cage. When he reached the veranda he saw the snake and jumped back as if frightened. The copper-

head struck at the bird, but was unable to reach it through the bars of the cage.

The evident suffering of its little friend aroused Jason's dander and he began to crawl toward the snake. His tail twitched and he licked his chops nervously. The snake was too intent on reaching the bird to notice the cat. Jason crouched a few feet from the cage and waited for the snake to come around. The copperhead slid around the cage, and when on the side near the cat raised its head to strike. As it did so Jason's form arched through the air and came down on the snake's body. There was a growl or two, a few sharp spits mixed with ugly hisses, and Jason was away from the snake with his back humped up and his tail like a scrub brush. The snake's skin had been torn by the cat's claws, but it had received no serious injury, and with its mad up to the top notch, it turned on the cat and made ready to spring. It didn't wait long before jumping, but when it landed Jason wasn't there, and before the copperhead knew what had happened it received a rake across the back from the cat's claws that made it run for the edge of the veranda, in the hope, no doubt, of sliding over and away from its assailant. But Jason had his fighting clothes on, and he didn't propose that the snake should get off so easily. Just as the copperhead began to slide over the edge of the porch, Jason grabbed it by the tail with his teeth and yanked it back. Once more the snake coiled and showed fight. It struck at the cat again, but the nimble-footed Jason was away, and once more raked the serpent's body with his claws. Again the snake attempted to escape, and again it was yanked back to the porch by the cat. This time Jason was a little slow in getting away, and the copperhead sank its fangs in his leg. The pain of the wound set Jason going at fine steam, and with a growl he snapped his teeth together through the snake's body about three inches below the head. The copperhead made an effort to break away, but Jason held on, and while he chewed the serpent's neck he lacerated its flesh with his claws.

This treatment was too much for the snake, and it shortly gave up the ghost. Jason finally let go the snake and went out into the garden and rolled in the dirt. His leg swelled up as big as a man's arm from the effect of the snake's bite, but he chewed catnip and rolled in the dirt a couple of hours, and then was about as good as new.—N. Y. Sun.

GALL FORMATION.

By Sophia Armitt.

The birds know better how to find the life that is inside galls than do human beings. In November and December they are searching among fallen oak leaves for the cherry galls, and opening them for the fat grubs that lie therein. An observer who is interested in the habits of birds, and had been watching them in the woods in December, 1893, brought in a lot of these cherry galls and placed them on moss inside a Dresden china cup in the family sitting room, to see what would come of them. In the course of a few days, quiet readers were frequently disturbed by the settling of peculiar flies upon them in a markedly unpleasant manner, causing involuntary and spasmodic starts. Upon investigation it was found that the gall flies were emerging from the galls, and the bird observer was requested to remove those galls to a different place. This circumstance was calculated to arouse curiosity. Were gall flies really maturing and emerging in winter? If so, how would they get along till the summer came and there were new oak leaves for them to put their eggs in?

Dr. Adler's book, reviewed in your last volume, page 88, entitled "Alternating Generations; a Study of Oak Galls and Gall Flies," solved these questions. These flies (Dryophanta scutillaris) do emerge, in any case, in winter from the cherry gall. It may be in nature they appear in January or in February, but always after a frost, for a thaw destroys the gall, which is their home. They are in this generation of only one sex, and they live only a few days. These flies search for little adventitious buds on the stem of the oak tree, wherein they place their eggs. In April the leaves from the buds, pricked by the flies, produce new galls, that are quite different from the cherry galls from which the flies emerged. These galls are dark violet and velvety, and are known as those of Spathegaster taschenbergi. In May and June the perfect flies of this new generation leave their galls. They are half the size of the mother or winter fly, and of two sexes. In a few days the females begin searching for the youngest and tenderest leaves, to prick the underside of the veins, and place there their eggs. In each pricked spot, when the egg hatches out as a grub, will begin to grow a new cherry gall, exactly like the one in which the grandmother passed the months which ended in the few days only of open-air existence.

The life story of the spangle gall (Neuroterus lenticularis) varies from this. Every one knows the pretty spangles beneath the oak leaves in July and onward. They fall, in autumn, on the leaves, but the life inside does not die with the leaf; it lives on through the winter, and the fly comes out in April or May. The gall fly immediately begins to examine buds carefully with its antennæ; when satisfied with a suitable one, it pushes its ovipositor deep therein, a long and difficult business, and lays one egg. When the bud expands, a small, round sappy gall is seen either under a leaf or on a male flower catkin. This is the currant gall (Spathegaster baccarum), smaller when on the flower than when on the leaf. From these the flies emerge in early June, male and female this time. The young, tender leaves are then sought for, and inside their under surfaces eggs are placed from which spangle galls will form, serving as a home for their tiny inmates, through summer and winter, till the next year's new growing time.

Much of Dr. Herman Adler's interesting book treats of the insects. There are minute descriptions of their forms and stages of life history. I have drawn the purely botanical parts together in the following paragraphs.

Galls occur on buds, leaves, flowers, bark or root; but, wherever they are, they originate always from the same parent tissue, from the formative cells that are called the cambium ring. A layer of this tissue extends through every plant, from the finest root fibers to the most distant leaves. All vegetable life springs from the cambium layer; its cells are the theater of actual metabolism, and yet they are not differentiated into a stable tissue. It is from these cells that all gall formation proceeds. When a gall fly pierces the cambium layer and deposits an egg there, gall formation does not certainly follow; it only begins when the larva emerges from the egg.

In this statement Dr. Adler differs from Sir John Lubbock and others, and he limits it to the action of oak gall flies, having observed that flies producing willow galls pour into the wound a secretion which causes new cell formation in the course of a few hours. On the oak tree procedure is different; it is only when the larva breaks through the egg case and touches the surrounding cells with its tiny mandibles that rapid cell growth is set up. Once begun, however, it goes on so quickly that while one end of the larva is still in its egg case, a wall-like mass of cells has risen up in front of it. This rapid cell growth is due to the irritation of the biting grub upon the highly formative cells of the cambium, which possess every condition for growth.

One gall fly (Trigonaspis crustalis) pricks the leaves in May; it drives its ovipositor into the vein of the leaf, leaving always a distinct mark. Months pass before any gall formation can be seen, it is not till September that the egg hatches out, and the delicate mandibles of the larva start the active cambium cells into gall formations. A gall is not parasitic in the surrounding tissue, it is of the same elements, only substituting itself for them by faster growth and still growing proportionately to the growth of the cellular layer around it. In a leaf gall the formation begins in the layer of formative cells on the under surface. Those of the upper surface having already become stable, they can undergo no further change, and therefore respond to no irritation: they are incapable of forming new cells. At first the cell growth only affects a small zone around it, but as it acquires a vascular system of its own it begins to grow as an independent structure. It is different when the eggs are laid in a bud. Then the biting larva touches rudimentary leaves consisting of still unmodified cells, all equally capable of development whether of upper or under surfaces. Then both surfaces take part in gall formation, and when the leaf comes to be unfolded it is found that there is an absence of leaf tissue, and that the resulting gall grows through the leaf substance.

Again, it is different when eggs are laid in the cambium layer of the bark. Here the cells which first form round the larva cannot be distinguished from adjacent cambium tissue, but in later growth there is a great contrast. The outer zone of the cambium ring produces the cells of the bast parenchyma, while the central zone of the cambium produces the wood parenchyma, and in these galls there is, too, a soft zone of sappy parenchymatous cells and a hard central zone of wood parenchyma. In all bark galls the woody center penetrates into the woody tissue of the tree, while the soft fleshy circumference proceeds from the bark. New cell growth is arranged in concentric layers round the larva, accompanied by changes in cell contents. The cells next the larva swell out, the cell contents become cloudy, and a multitude of starch granules appear. The rudimentary gall draws its first nourishment from the surrounding tissue, later it is more independent, for a new element comes in. From the spiral vessels lying in the cambium ring processes are driven into the rudimentary gall; the entrance of these vessels occurs at a definite spot on the lower surface of the gall, whether it is connected with the parent tissue by a broad base or a small stalk. The gall has now become an independent structure and is practically withdrawn from the direct influence of the cellular area around it, from which it sprang. Its individuality of organization is shown by complicated transmutations of cells originally alike, especially in the cells of the exterior, which develop peculiar pigments and hairs of various kinds, both in great variety of forms. It is the value of these different structures, as protective contrivances, which has secured their evolution by the gall. Sometimes the hairs exude a sticky sap which keeps off parasites. Even smooth galls, like Aphiloterix sieboldi, secrete a juice which attracts ants. These protect the galls, like sentinels, driving other insects off and often constructing a protective mantle of earth around them. If the larva perishes before the gall is mature, its formation is stunted. The influence of the larva is necessary not only for the commencement but for the completion of the gall. When a roundish inner gall is found undeveloped, parasites are always present. A gall pricked by parasites grows in an anomalous manner. Galls contain not only the larvæ that form them, they are often taken possession of by insects that are called "inquilines" or lodgers of the oak gall flies. These creatures enhance the natural difficulties of observation of gall formation; they are so nearly related to the true gall flies that they can only be distinguished by the minutest characteristics. It is not doubted that they have developed from the true gall flies. By the use of a gall already formed the prosperity of their progeny is more certainly insured. Unfortunately, these lodger flies are more easily reared and collected than the true gall makers. The gall fly proceeds with great care in the choice of tender leaves, or terminal buds, or flower buds, but in spite of its care galls often fail to appear where eggs have been laid. The greatest number fail in the buds where only one egg is laid. Species emerging in summer can only prick winter buds which are waiting the coming of the next growing period, and in many seasons a premature and anomalous development of winter buds may be absent. This is not the only reason; the egg must be placed exactly in the cambium ring, which lies like a fine seam in the base of the bud, and if the egg is not laid in this fine seam, it perishes without forming a gall. Considering the difficulty to be overcome in placing the egg in precisely the right spot, it is not surprising if many eggs are laid amiss. Failures occur less frequently in leaf galls pricked in bud, because the fly has choice of much wider territory—the whole of the rudimentary leaves in the bud. Failures are not usually observed at all where the fly pricks the surface of bark or leaf, because the cell region to be struck is always at one uniform depth below the surface. Gall formation is dependent on the growing period of the tree, and ceases at its close. Most galls mature in the space of a year. Those which require two years are bark galls; the first year the rudiment is formed and then development ceases till the next spring, when it is resumed with the new period of vegetative activity.

Dr. Adler's book is beautifully illustrated; all the galls he experimented upon are portrayed in color. The greater part of the volume is occupied by a detailed account of his years of experiments and observations on the oak galls and their inmates. The life cycle of each gall fly is made up of two generations, each one of which produces its own sort of gall different from the other. One generation consists of two sexes, the other of one only. The life of the gall fly is generally very short, of days only, while the life of the insect inside the gall may be months or years. These facts seem to be common to all the gall flies investigated. Many of the life stories are more curious than the two I have only touched upon as being perhaps the best known galls. There are the artichoke galls, the oak apples, and the marble galls; but your readers will doubtless prefer to have the best part of an interesting book to study for themselves.—Science-Gossip.

[Nature.]

A FEW MORE WORDS ON THOMAS HENRY HUXLEY.

Two scenes in Huxley's life stand out clear and full of meaning, amid my recollections of him, reaching now some forty years back. Both took place at Oxford, both at meetings of the British Association. The first, few witnesses of which now remain, was the memorable discussion on Darwin in 1860. The room was crowded, though it was a Saturday, and the meeting was excited. The bishop had spoken; cheered loudly from time to time during his speech, he sat down amid tumultuous applause, ladies waving their handkerchiefs with great enthusiasm; and in almost dead silence, broken merely by greetings which, coming only from the few who knew, seemed as nothing, Huxley, then well nigh unknown outside the narrow circle of scientific workers, began his reply. A cheer, chiefly from a knot of young men in the audience, hearty but seeming scant through the fewness of those who gave it, and almost angrily resented by some, welcomed the first point made. Then as, slowly and measuredly at first, more quickly and with more vigor later, stroke followed stroke, the circle of cheers grew wider and yet wider, until the speaker's last words were crowned with an applause falling not far short of, indeed equaling, that which had gone before, an applause hearty and genuine in its recognition that a strong man had arisen among the biologists of England.

The second scene, that of 1894, is still fresh in the minds of all. No one who was present is likely to forget how, when Huxley rose to second the vote of thanks for the presidential address, the whole house burst into a cheering such as had never before been witnessed on any like occasion, a cheering which said, as plainly as such things can say: "This is the faithful servant who has labored for more than half a century on behalf of science with his face set firmly toward truth, and we want him to know that his labors have not been in vain." Nor is any one likely to forget the few carefully chosen, wise, pregnant words which fell from him when the applause died away. Those two speeches, the one long and polemical, the other brief and judicial, show, taken together, many of the qualities which made Huxley great and strong.

Among those qualities perhaps the most dominant, certainly the most effective as regards his influence on the world, were on the one hand an alertness, a quickness of apprehension, and a clear way of thinking, which, in dealing with a problem, made him dissatisfied with any solution incapable of rigid proof and incisive expression—he seemed always to go about with a halo of clear light immediately around him; and, on the other hand, that power of foreseeing future consequences of immediate action which forms the greater part of what we call sagacity. The former gave him his notable dialectic skill, and mark all his contributions to scientific literature; the latter made him, in addition, an able administrator and a wise counselor, both within the tents of science and beyond. These at least were his dominant intellectual qualities; but even more powerful were the qualities in him which, though allied, we distinguish as moral; and perhaps the greater part of his influence over his fellows was due to the fact that every one who met him saw in him a man bent on following the true and doing the right, swerving aside no tittle, either for the sake of reward or for fear of the enemy, a man whose uttered scorn of what was mean and cowardly was but the reciprocal of his inward love of nobleness and courage.

Bearing in mind his possession of these general qualities, we may find the key to the influence exerted by him on biological science in what he says of himself in his all too short autobiographic sketch, namely, that the bent of his mind was toward mechanical problems, and that it was the force of circumstances which, frustrating his boyish wish to be a mechanical engineer, brought him to the medical profession. Probably the boyish wish was merely the natural outcome of an early feeling that the solution of mechanical problems was congenial to the clear decisive way of thinking to which I referred above, and which was obviously present even in the boy; and that it was not the subject matter of mechanical problems, but the mode of treating them which interested him, is shown by the incident recorded by himself, how when he was a mere boy a too zealous attention to a postmortem examination cost him a long illness. It is clear that the call to solve biologic problems came to him early; it is also clear that the call was a real one; and as he himself has said, he recognized his calling when, after some years of desultory reading and lonely irregular mental activity, he came under the influence of Wharton Jones at Charing Cross Hospital. That made him a biologist, but confirmed the natural aptitude of his mind in making him a biologist who, rejecting all shadowy intangible views, was to direct his energies to problems which seemed capable of clear demonstrable proof. In many respects the biologic problems which lend themselves most readily to demonstrable solutions capable of verification are those which constitute what we call physiology; and if at the time of his youth the way had been open to him, Huxley

would probably have become known as a physiologist. But at that time careers for physiologists were of the fewest. His master, Wharton Jones, a physiologist of the first rank, whose work in the first half of this century still remains of classic value, had been driven to earn his bread as an ophthalmic surgeon, and an even greater physiologist, William Bowman, was following the same course. There was no opening in physiology for the young student at Charing Cross, and he was driven by stress of circumstances to morphological rather than to strictly physiological problems; but it was not until long after, when he had achieved eminence as a morphologist, that he finally abandoned his old wish to hold a physiological chair.

Looking back on the past, we may now be glad that circumstances were against his wishes; for (though in every branch of science there is need at all times of a great man) there was at the middle of the century, in the early fifties, a special need in morphology for a man of Huxley's mould. Richard Owen was then dominant, and it is an acknowledged feature of Owen's work that in it there was a sudden leap from most admirable detailed descriptive labor to dubious speculations, based for the most part on, or at least akin to, the philosophy of Oken. Of the "new morphology" in which Johannes Muller was leading the way, and the criteria of which had been furnished by the labors of Von Baer, there was then but little in England save, perhaps, what was to be found in the expositions of Carpenter. Of this new morphology, by which this branch of biology was brought into a line with other exact sciences, and the note of which was not to speculate on guiding forces and on the realization of ideals, but to determine the laws of growth by the careful investigation, as of so many special problems, of what parts of different animals, as shown among other ways by the mode of their development, were really the same or alike, Huxley became at once an apostle.

His very first work, that on the Medusæ, wrought out amid the distractions of ship life, written on a lonely vessel plowing its solitary way amid almost unknown seas, away from books and the communion of his fellow workers, bears the same marks which characterize his subsequent memoirs; it is the effort of a clear mind striving to see its way through difficult problems, bent on holding fast only to that which could be proved. This is not the occasion to insist in detail on the value of the like morphological work which he produced in the fifties and the sixties or to show how he applied to other forms of animal life, to echinoderms, to tunicates, to arthropods, to mollusks, and last though not least to vertebrates, the same method of inquiry which guided the work on the Medusæ. Nor need I dwell on the many valuable results which he gained for science by attacking in the same spirit the problems offered by the remains of extinct forms. Moreover, he strengthened the effect of his own labors by admirable expositions of the results of others.

Further, unlike his great predecessor, who formed no school and had few if any disciples, it was Huxley's delight to hold out his hand to every young man whom he thought could profit by his help, and before many years were over his spirit was moving in the minds of many others. Thus it came about that during the latter half of this century, owing largely to Huxley's own labors and to the influence which he exerted not only in England but abroad, there has been added to science a large body of morphological truths, truths which have been demonstrated and must remain, not mere views and theories which may be washed away.

The excitement of the Darwinian controversy, with its far-reaching issues, has been apt to make us forget how great has been the progress of animal morphology during the past half century. Undoubtedly the solution of special problems touching animal forms and the great theory of natural selection through the struggle for existence have been closely bound together; the special learning has furnished support for the general theory, and the general theory, besides strongly stimulating inquiry, has illumined the special problems. But the two stand apart, each on its own basis; and were it possible to wipe out, as with a sponge, everything which Darwin wrote, and which his views have caused to be written, there would still remain a body of science touching animal forms, both recent and extinct, acquired since 1850, of which we may well be proud. In the gaining that knowledge Huxley, as well by his own labors as by his influence over others, stands foremost, Gegenbaur being almost his only peer; and had Huxley done nothing more, his name would live as that of one of the most remarkable biologists of the present century.

As we all know, he did much more; his influence on England and on the world went far beyond that of his purely scientific writings. But when we reflect that a hundred years hence the image of the man as he went to and fro among men, so bright and vivid to-day, will have become dim and colorless, a shadow as it were, and that then the man will be judged mainly by the writings which remain, we must count these writings as the chief basis of his fame. And, though we may think it possible that the world of that day, much that is unwritten having been forgotten, may find it in part difficult to understand how great a power Huxley was in his time, the lapse of years will we may be sure in no way lessen, it may be will heighten, the estimate of his contributions to exact science.

As we all know, he did much more. To the public outside science he first became known as the bold, out spoken exponent and advocate of Darwin's views, and indeed to some this is still his chief fame. There is no need here to dwell on this part of his work, and I speak of it now chiefly to remark that the zeal with which he threw himself into this advocacy was merely a part of the larger purpose of his life. Science, or, to use the old phrase of the Royal Society, natural knowledge, had a twofold hold on Huxley. On the one hand he felt deeply all the purely intellectual, and if we may use the word, selfish joys of fruitful progressive inquiry after truth. This was dominant in his early days, and to it we owe the long list of valuable researches, of which I just now spoke, and which followed each other rapidly in the fifties and the sixties. On the other hand, feeling deeply, as he did, his duties as a citizen of the world, science laid hold of him as being the true and sure guide to conduct man in all his ways; and this latter working of science in him, evident even in early days (witness his Address to Working Men at St. Martin's Hall in 1854), grew stronger and stronger as the years went on, until at last it took almost entire possession of him.

To him, indeed, it may be said, science was all in all. He saw, as others see, in science a something which is broadening and strengthening human life by unceasingly bending nature to the use of man, and making her resources subservient to his desires; he saw the material usefulness of science, but he saw something more. He saw also, as others see, in science, a something in which the human mind, exercising and training itself, makes itself at once nimble and strong, and dwelling on which is raised to broad and high views of the nature of things; he saw in science a means of culture, but he saw something more. He saw in science even as it is, and still more in science as it will be, the sure and trustworthy guide of man in the dark paths of life. Many a man of science goes, or seems to others to go, through the world ordering his steps by two ways of thinking.

When he is dealing with the matters the treatment of which has given him his scientific position, with physical or with biological problems, he thinks in one way; when he is dealing with other matters, those of morals and religion, he thinks in another way; he seems to have two minds, and to pass from the one to the other according to the subject matter. It was not so with Huxley. He could not split himself or the universe into two halves, and treat the one and the other half by two methods radically distinct and in many ways opposed; he applied the one method, which he believed to be the true and fruitful one, to all problems without distinction. And as years came over him, the duty of making this view clear to others grew stronger and stronger. Relinquishing, not without bitter regret, little by little, the calm intellectual joys of the pursuit of narrower morphological problems, he became more and more the apostle of the scientific method, driven to the new career by the force of a pure altruism, not loving science the less, but loving man the more.

And his work in this respect was a double one; he had to teach his scientific brethren, at least his biologic brethren, the ways of science, and he had to teach the world the works of science. It was this feeling which, on the one hand, led him to devote so much labor to the organization of biologic science in order that his younger brethren might be helped to walk in the straight path and to do their work well. It was this feeling, on the other hand, which made him urgent in the spread of the teaching of science. It was this, and no vain love of being known, which led him to the platform and the press. The zeal with which he defended the theory of natural selection came from his seeing the large issues involved; to him the theory was a great example of the scientific method applied successfully to a problem of more than biologic moment, while the fierceness of his advocacy was a natural expression of resentment on the part of one who saw a scientific conclusion, gained with unstinted pains and large reasoning, judged contemptuously by men who knew nothing of science according to methods in which science had no part.

Science, under this aspect, is a part of what is sometimes called philosophy; and though Huxley felt in common with others, and felt deeply the pleasures of the intellectual wrestler, struggling with problems which, seemingly solved and thrown to the ground, spring up again at once in unsolved strength, it was not these pleasures alone which led him, especially in his later years, to devote so much time and labor to technical philosophic studies. He hoped out of the depths of philosophy to call witnesses to the value of the scientific method. Indeed, nearly all the work of the latter part of his life, including the last imperfect fragment, written when the hand of disease which was to be the hand of death was already laid upon him, and bearing marks of that hand, was wrought with one desire, namely, to show that the only possible solutions of the problems of the universe were such as the scientific method could bring. This was at the bottom of that antagonism to theology which he never concealed, and the existence of which no one who wishes to form a true judgment of the man can ignore.

He recognized that the only two consistent conceptions of man and the universe were the distinctly theologic one and the scientific one; he put aside as unworthy of serious attention all between. He was convinced that the theologic conception was based on error, and much of his old age was spent in the study of theologic writings, whereby he gathered for himself increasing proof that there was no flaw in the judgment which had guided his way from his youth upward. Not only so, but he was no less convinced that, owing to what he believed to be the essential antagonism of the theologic and the scientific methods, the dominance of the former was an obstacle to the progress of the latter.

But while on the objective side his scientific mode of thought thus made him a never-failing opponent of theologic thought of every kind, a common tie on the subjective side bound him to the heart of the Christian religion. Strong as was his conviction that the moral no less than the material good of man was to be secured by the scientific method alone, strong as was his confidence in the ultimate victory of that method in the war against ignorance and wrong, no less clear was his vision of the limits beyond which science was unable to go. He brought into the current use of today the term "agnostic," but the word had to him a deep and solemn meaning. To him "I do not know" was not a mere phrase to be thrown with a light heart at a face of an opponent who asks a hard question; it was reciprocally with the positive teachings of science the guide of his life. Great as he felt science to be, he was well aware that science could never lay its hand, could never touch, even with the tip of its finger, that with which our little life is rounded, and that unknown dream was a power as dominant over him as was the might of known science: he carried about with him every day that which he did not know as his guide of life no less to be minded than that which he did know. Future visitors to the burial place on the northern heights of London, seeing on his tombstone the lines—

"And if there be no meeting past the grave,
If all is darkness, silence, yet 'tis rest.
Be not afraid, ye waiting hearts that weep,
For God still 'giveth his beloved sleep,'
And if an endless sleep He wills, so best"—

will recognize that the agnostic man of science had much in common with the man of faith.

There is still much more to say of him, but this is not the place to say it. Let it be enough to add that those who had the happiness to come near him knew that besides science and philosophy there was room in him for yet many other things; they forgot the learned investigator, the wise man of action, and the fearless combatant as they listened to him talking of letters, of pictures, or of music, always wondering which delighted them most, the sure thrust with which he hit the mark, whatever it might be, or the brilliant wit which flashed around his stroke. And yet one word more. As an object seen first at a distance changes in aspect to the looker-on who draws nearer and yet more near, features unseen afar off filling up the vision close at hand, so he seemed to change to those who coming nearer and nearer to him gained a happy place within his innermost circle; his incisive thought, his wide knowledge, his sure and prompt judgment, his ready and sharp word, all these shrunk away so as to seem but a small part of him; his greater part, and that which most shaped his life, was seen to be a heart full of love which, clinging round his family and his friends in tenderest devotion, was spread over all his fellow men in kindness guided by justice.—M. Foster.

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